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and

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Competition from Plastics

A few weeks ago we dealt with the question of the competition to which castings are submitted from wrought and plastic materials. Much of what we then said has been reinforced by Papers presented to the Paris Conference. It thus seems germane to quote from Report No. 16 of the Fifth Census of Production in order to show the real progress made by the plastics industry. The value of the output rose from £6,239,000 in 1934 to £7,275,000 in 1935, whilst the number of persons employed increased from 19,349 to 22,579. So far as the ironfoundry industry is concerned, it has to meet and overcome competition in such components as meter and circuit-breaker cases, counter weighing-machine housings and similar work. The tensile strength of plastics is usually of the order of 3½ tons per sq. in., a compression strength in the region of 13 tons is considered normal, and the impact strength is somewhere about 2 ft.-lbs. per sq. in. These compare with, say, 14 tons tensile, 70 tons compression and a minimum impact strength of 10 ft.-lbs. per sq. in. for a good grade of cast iron. Thus, on a mechanical-strength basis, there is much to be said in favour of cast iron. Appearance, however, is of outstanding importance in the case of counter weighing scales, but still first place must be given to vitreous enamelled cast iron, and to a thinking person a modicum of weight is no real disadvantage, as a machine needs to remain in exactly the same place, without the necessity of being screwed down to the counter. Moreover, personal experience has failed to convince us that plastic mouldings do not warp with the passage of time, whilst the low impact figure seems to denote brittleness. Probably aluminium die-castings have received a fair amount of competition from plastics, and the answer must be in the direction of bestowing colour by anodising, or perhaps stove-enamelling or some other process. Again, personal experience has shown that the colour of plastic mouldings, initially never too pleasing, is not too permanent, pure white being badly susceptible to discoloration. Naturally, there is a credit side to this industry, and no doubt it has bought a few hundred thousands of pounds worth of castings incorporated in the various presses and press tools which are used. Intelligently handled, competition from plastic mouldings need not cause foundrymen too many sleepless nights. After all, the foundry industry has no particular interest in ash trays, fountain-pen bodies and collapsible tube caps.

New Factories

The data recently issued by the Board of Trade show that in 1936 the number of new factories established was 551, giving employment for 53,000. It is surprising how closely the average number of employees in the factories started in various parts of the country comes to 100. The number of factories extended last year was 201, and the number closed was 161. Of the new factories established, 24 are classed as from foreign countries. The Board of Trade does not find any evidence of the southern drift of industry, that is, the direct transfer of establishments from the North to the South of England, but there is no doubt that new enterprise is predominantly centred in the South. The 261 factories started in Greater London with 20,050 employees represent something approaching one-half of the new establishments started and over a third of the labour absorbed, and no other area can show anything like this proportion. There is no detailed classification of the types of factories built and the industries served, and little doubt exists that the southern establishments include many of the light industries so common to-day, from the manufacture of radio sets to cosmetics, but heavy industrial work is likely to remain centred in the Midlands and the North. The new works in the iron and steel group numbered 38, of which 12 are in Greater London, 11 in the North-East, and nine in the Midlands. In the engineering group, 32 works were started, of which there were 13 in Greater London, seven in the Midlands and six in the North-West. In the motor and cycle industries, of 11 new factories, Greater London claims seven and the Midlands three. In the non-ferrous metals group, the Midlands has four of 11 new works. It would be of interest to know how far the new southern plants are assembling materials and parts drawn from or fabricated elsewhere.

High-Duty Iron

MR. R. S. MACPHERRAN in a Paper, "Cupola-melted High Test Iron," which he presented to the annual meeting of the American Foundrymen's Association, gives the following information.

High-duty iron can be produced with or without the addition of alloys. If any foundryman wishes to increase the machinability and perhaps close the grain of his iron, he may add ½ to 1 per cent. nickel. Or he may use copper for somewhat the same purpose. In former years copper was thought to make iron red short. Many tests have been made at temperatures up to 650 deg. C. of irons containing 1 per cent. copper and no greater loss of strength than usual in other irons has been found. The cupola used by the author to make his iron was of 54-in. inside diameter, having 6 tuyeres in one row. These tuyeres were 19 in. long by 5 in. in height, and were equally spaced round the cupola. The upper edge was 19 in. above the sand bottom. The coke bed weighed 2,300 lbs. and the iron charges 3,000 lbs. There was an average of about 325 lbs. of coke used between the charges.

The iron charge consisted of 80 per cent. steel; 8 per cent. to 10 per cent. return high-duty iron scrap; 8 per cent. silvery pig; 1 to 2 per cent. Northern pig (Si 2 to 3 per cent.) and 2 per cent. ferro-silicon. In the spout there was added 3 lbs. of ferro-manganese silicon for each thousand lbs. of iron in the ladle. This ferro-manganese silicon contained 50 per cent. silicon and 25 per cent. manganese, the remainder being iron. This gave a composition of: Si, 2.25; S, 0.10; Mn, 0.80; P, < 0.10 per cent.; and Cr, 0.20. The total carbon was usually about 2.80, although the first ladle sometimes exceeded that amount.

To avoid high carbon of the first iron, 2 or 3 charges of a mixture without scrap and about 87 per cent. steel were used. As this iron must be poured hot, no effort was made to reduce the amount of coke on the bed or between charges. The absorption of carbon is one largely of opportunity and a high bed and a large amount of coke in the cupola tends to increase the carbon in the ladle. Short taps were made, and the iron was kept in the cupola as short a time as possible. While a high temperature probably increases the absorption of carbon, very hot melts were always made. The blast pressure was 6 ounces. About 65 lbs. of limestone were used per charge, while the by-product coke used contained up to 8 per cent. ash and 0.7 per cent. sulphur.

The risers were made larger than usual and the iron was poured into the mould as rapidly as possible. This metal had a short freezing range and very little internal shrinkage. Short gates should be used.

The Sir John Cass Technical Institute

The new session of the Sir John Cass Technical Institute, Jewry Street, Aldgate, London, E.C.3, will begin on September 20, and students will be enrolled on and after September 15. Amongst subjects in which evening instruction is provided are pure and applied mathematics, physics, chemistry, petroleum technology, fuel technology (including coal carbonisation and gas engineering (manufacture)), chemical enginering, metallurgy, assaying and geology. These courses are arranged to meet the requirements of those engaged in chemical, metallurgical, electrical, petroleum and similar industries, and are held from 6 to 10 p.m. Day courses are also provided in some subjects, including physics, mathematics, chemistry and metallurgy. Full facilities are provided in well-equipped laboratories for special investigations and research. The instruction in experimental science also provides systematic courses for the examination of the University of London, the Institute of Physics, the Institute of Chemistry, the Institution of Gas Engineers, and the City and Guilds of London Institute. The Principal and heads of departments will be pleased to advise intending students at the commencement of the session on the course they should undertake.

American Notes

The Ford Motor Company of Detroit has awarded a contract to the Koppers Company, of Pittsburgh, for the construction of an additional battery of 61 coke ovens at their Rouge plant. The battery will increase the present gas supply by 25 per cent. to some 40,000,000 cub. ft. daily. The new ovens will also yield 1,125 tons of coke, and will increase the by-product output by 25 per cent.

* * *

Before dyeing, mohair fabrics are washed and then run through squeeze rolls to wring out the water. These rolls formerly were made of ordinary cast iron, which would acquire rust coatings when the plant was closed at week-ends and then pit. One large manufacturer installed some test rolls of "Ni-Resist" made by Cramp Brass and Iron Works of Philadelphia, Pa. These have been in service for more than three months with excellent results.

THE FOUNDRY TRADES' EXHIBITION

Our issue of September 16 is to be devoted to a comprehensive description of the plant and machinery shown in the Foundry Exhibition which opens on that day. Extended details of the welding section and shorter notes on the materials displayed in the general engineering exhibition will also be given.

With the addition of a new 25-ton electric furnace to its steel capacity, Allegheney Steel Company now has a capacity of producing 500,000 tons of steel a year. The new electric furnace adds 36,000 tons annually to alloy steel capacity of the plant.

* * *

The United States Steel Corporation has started production of a colour motion picture depicting the making of steel in its various mills. The film, which will cost more than £40,000, will be made by Technicolor, Inc., and is said to be the first industrial educational picture to use colour photography.

* * *

Sir James Dunn, of the Alcoma Steel Corporation, has stated that the new Helen Mine, north of Sault Ste. Marie, will be brought into production at an initial rate of 2,000 tons a day. The mine is a definite forward step toward independence for Canada in its iron-ore supply, with the possibility that the British Empire may also be supplied. About half the output will be used by Algoma Steel Company and the balance will be sold to other Canadian mills.

* * *

Republic Steel Corporation has announced a £400,000 expansion programme for its Gulf States Steel Division. Two 150-ton open-hearth steel furnaces will be added, increasing its open-hearth capacity by 50 per cent.

* * *

The Lewis Foundry & Machine Company has enlarged its manufacturing facilities and increased its total floor space by approximately 50 per cent. Additional modern machinery installed includes roll grinders, boring mills and gear cutting machinery.

Random Shots

It has come at last! Railway wagons are going to have shock absorbers and the days of musical shunting are numbered. People who live near a railway siding will be able to sleep the sleep of the righteous once more. "Marksman" confesses, however, that he will miss a certain favourite "glapping train which goes "glap, glap" down the line in the dead of night, and which has become quite a friend in the dark. Whilst one hopes that goods trains will be less noisy in the future, one can hardly hope that nothing will ever get broken in transit! However, foundrymen on holiday, waiting for a connection at Layer-atte-Bower, can amuse themselves placing pennies on a passing wagon to test its shock-absorbing properties, in the same way that they do in foundry exhibitions with the jar-ramming machine tables.

* * *

At the forthcoming Foundry Exhibition, by the way, one firm is going to have a milk bar. (Idea strictly copyright!) What is the motive behind the strange fact that whilst this milk bar is sure to be in a prominent position, the bar which really matters has, ever since exhibitions first began, always been hidden behind closed doors? Are men afraid of their fellow beings discovering a secret vice, or has it anything to do with relative prices—whiskey averaging 12s. 6d. a pint, whilst milk is only 3d. a pint? It is, of course, well known that there are many Scotchmen in the foundry game and standing a round of drinks at the milk bar is less likely to prove a drain on the pocket! "Marksman" is no supporter of this milk-bar craze within the industry. It takes beer to produce the "he-men" needed for foundry work. In fact, it has been recorded in an old book on the trade, dating over 100 years ago, that journeymen moulders were often paid twice weekly because they were known to be very partial to large quantities of porter.

* * *

As a result of much lounging about on haystacks in an uncommonly peaceful corner of England and being without a daily paper until the early afternoon, "Marksman" has evolved several ideas for ensuring international peace. The first is to call the countries by numbers instead of by names, and statesmen to be anonymous. Personal ambition would sink into oblivion, and it would be hard for country 18 to show its teeth with any real effectiveness at number 27.

* * *

Another way would be to make it compulsory for every girl within the next fifty years to marry a foreigner. One would think twice, then, of making rude remarks about "them blinking foreigners!"

* * *

The third way would be to run the League of Nations on the lines of the Football Association, with a 1st, 2nd and 3rd league—points being awarded for surpluses in the Budget, and two countries going up and two down at the end of each season.

* * *

Everyone will sympathise with Mr. J. T. Goodwin, a Past-President of the I.B.F., who has lost his pet crow, one Jimmy by name. Has Mr. Goodwin thought of searching for Jimmy in the B. & S. foundry in Scotland, where nests are to be found above the crane track? None of the thousand crows that "Marksman" met in the fields on his holiday answered to the name of Jimmy, but perhaps other holiday-making friends will thus help in the search. It is to be hoped that they won't get as hoarse as "Marksman" did for it cost him a pint at every pub. With the aid of the Costing Sub-Committee, however, such expenses could be allowed when fixing the reward to the lucky finder.

"MARKSMAN."

Heat-Treatment of Large Nickel-Chromium Steel Castings*

By J. OBREBSKI

The wide use of special steels for the manufacture of castings should direct attention to a rational heat-treatment for developing the maximum mechanical properties in cast steels. A casting weighing one or more tons is so valuable that it would be unforgivable not to do everything possible to avoid all the defects which would cause the casting to be wasted in heat-treatment. Preliminary investigations will always be very profitable in this direction.

The theses set out in the present Paper are based on several years' experience, as well as particular researches dating from 1932, and the author will endeavour to substantiate his views by examples and diagrams.

It has been established that every heat-treatment of nickel-chrome steel castings should be preceded by a normalising anneal, and for this purpose elevated temperatures need not be feared. The best results will be obtained in the region of 900 to 950 deg. C., but one can heat up to 1,000 deg. without apprehension, the duration of heating depending upon the thickness of the casting. Cooling can take place in the furnace; then one can pass on to the heat-treatment when the casting has cooled to 400 deg., that is to say, complete cooling is unnecessary.

To secure a casting having the best mechanical properties the second operation must be to quench and temper. The weight and size of the castings, however, do not always permit of these standard methods. Quenching in oil, or in the salt bath (isothermic quench), or even a quench in molten metal heated to 150 to 200 deg. C., presents serious difficulties when large castings are being dealt with. It calls for immense vats and lifting equipment allowing heavy castings to be lowered with sufficient speed to avoid ignition of the oil or decomposition of the salts. A quenching bath of adequate volume, as well as the ancillary plant, would be very expensive. Other means must be sought, therefore, among which can be mentioned—dependent on the composition of the steel—water-spraying or cooling by compressed air, or a combination of both.

Before everything else, one must study the rate of cooling in the laboratory, and determine the temperature intervals for which this cooling should be rapid, as well as the temperatures where the rate of cooling does not exert any influence on the structure sought.

Preliminary tests should be carried out on forged test-pieces derived from the same tap as the casting. The heat-treatment giving the best results on the forged test-pieces will be the most favourable for the casting, and the forging of the test-pieces will permit a certain number of accidental faults to be avoided. At this point the author ought to state precisely that a sound casting is able to take on mechanical characteristics very near to those of the forged test-pieces. This subject will be dwelt upon later.

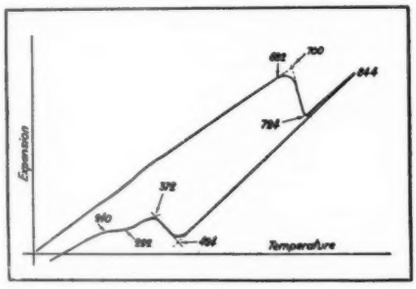


FIG. 1.—HEATED FOR 3 HRS.; COOLED 4 HRS.

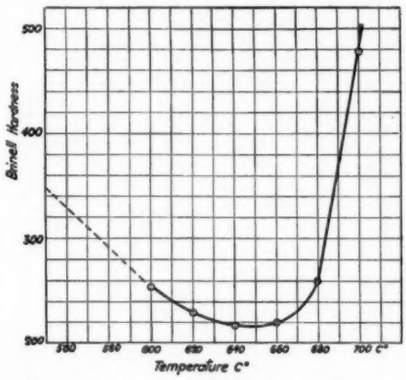


FIG. 2.—BRINELL HARDNESS RELATED TO TEMPERING TEMPERATURE.

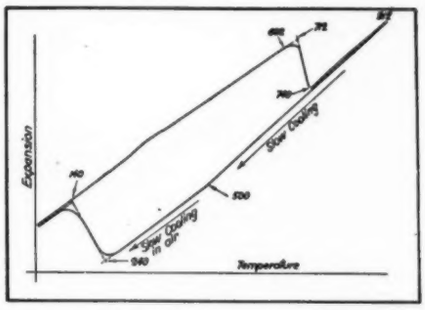


FIG. 3.—HEATED 3 HRS.; COOLED 2½ HRS. TO 500 DEG. C., THEN COOLED IN AIR.

Preliminary Laboratory Studies

The laboratory researches described below relate to a steel of the following composition: C, 0.30; Ni, 3.52; Cr, 0.89; Mn, 0.70; Si, 0.34; S, 0.02 and P, 0.015 per cent., and produced in the basic open-hearth furnace. Fig. 1 shows an expansion diagram, drawn with the Leitz universal dilatometer, for a 3-hr. heating and 4-hr. cooling period, and indicates the hardening and tempering temperatures.

To determine more exactly the highest temperature giving the minimum hardness value, a number of test-pieces were quenched in oil at 820 deg. C., then reheated to 600 to 700 deg. and quenched in water at 20 deg. Then the hardness was measured. The results are given in Fig. 2, which shows that the tempering should be carried out at a temperature of 640 to 660 deg. The breaking strength thus obtained exceeded the required values, while the resilience was at a maximum.

These preliminary tests allow the temperatures of the standard heat-treatment process to be determined, *i.e.*, the temperatures of quenching and tempering.

Next the cast was examined from the point of view of temper brittleness, which phenomenon is known as the "Krupp defect." The relevant figures are given in the tables below.

There still remains an outstandingly important problem, namely, to define the influence of the rate of cooling from temperatures which lie above the temperature of the Ac_3 point. Fig. 3 shows the ease with which the critical points Ar_3 and Ar_1 can be lowered. This phenomenon is too well known to be discussed at length. It is evident that slow cooling down to 724 deg. C. or even 682 deg. cannot at all influence the temper of the steel set out above if it be followed by a very rapid cooling.

Just the same, it has been decided to examine the influence of a very slow cooling in the region of 650 deg., 550 deg and 450 deg. C. It can be admitted that, in passing very slowly from one of these temperatures to the other, the influence of speed will be nil, in other words one can remain at each of these temperatures for quite a long time. It has been established that if the temperature of 650 deg. C. be maintained for 3 hrs. no influence will be observed. The diagram thus drawn is shown in Fig. 1.

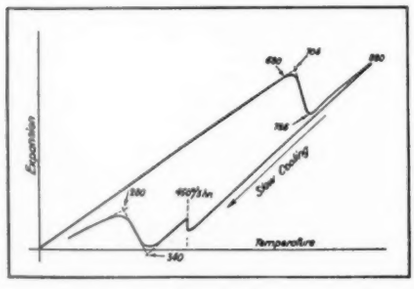


FIG. 4.—COOLED FOR 2 HRS. DOWN TO 450 DEG. C.; HELD AT THIS TEMPERATURE FOR 3 HRS., THEN COOLED FOR 1.5 HRS.

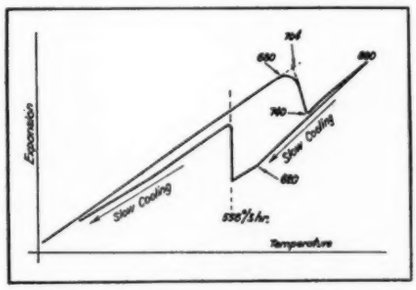


FIG. 5.—COOLED 1 HR. DOWN TO 620 DEG. C. THEN MORE SLOWLY TO 556 DEG. C., AT WHICH IT WAS HELD CONSTANT FOR 3 HRS., AND THEN COOLED FOR 2 HRS.

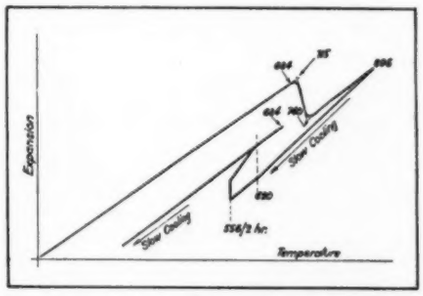


FIG. 6.—COOLED TO 620 DEG. C., THEN MORE SLOWLY TO 556 DEG., HELD CONSTANT AT THIS TEMPERATURE FOR 2 HRS., THEN REHEATED TO 684 DEG. C. AND COOLED.

By maintaining the temperature of 450 deg. C. for 3 hrs., the curve obtained undergoes some changes, shown in Fig. 4. A more noticeable result will be obtained, however, by maintaining the temperature of 550 deg. C. for 3 hrs. At this temperature complete decomposition of the austenite is effected, and it can be said that the Ar_3 and Ar_1 points are here mixed up and

* Paper (slightly abridged) presented at the International Foundry Congress at Paris.

that the temperature of these points is 550 deg. C. This phenomenon is known as "isothermic softening."

A similar result can be obtained in 2 hours; it is necessary, however, to raise the temperature anew to 650 to 680 deg. C. Fig. 6 reproduces the diagrams obtained in this case, and Fig. 5 shows the isothermic softening at 550 deg. for 3 hours.

It has been established that a marked softening of the steel can be obtained by the treatment represented in Fig. 7.

The heat-treatment process carried out according to the author's new method (see Fig. 6) is made up of heating to a temperature above the Ac_3, a slow cooling down to 550 deg. C. carried out in any manner (obviously, for the steel set

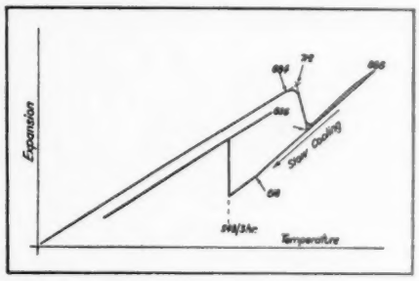


FIG. 7.—COOLED SLOWLY TO 618 DEG. C., THEN EXTREMELY SLOWLY TO 548 DEG. C., HELD CONSTANT AT THIS TEMPERATURE FOR 3 HRS. THEN COOLED SLOWLY.

out above), an isothermic softening at 550 deg. C. for 3 hours, followed by a fresh heating to 650 to 680 deg. and a *very quick* cooling from this last temperature.

Hardness Tests

The test-pieces were heated to a temperature of 850 deg. C. in an electric resistance furnace and were plunged into lead baths at 600, 590, 580 deg. C., etc., down to 550 deg., the last temperature being (see above) the most favourable for the decomposition of the austenite.

The test-pieces were kept in the lead bath for a period varying from 15 minutes up to 5 hours, then quenched in oil, after which hardness measurements were taken. The results of these tests are summarised in Fig. 8. It is clearly

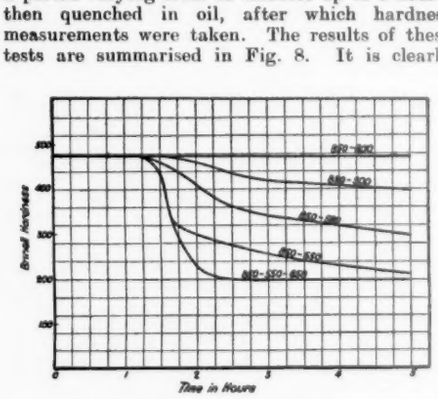


FIG. 8.—BRINELL HARDNESS RELATED TO HEAT-TREATMENT.

seen here that the test-pieces can be maintained for an hour at each of the temperatures indicated without any noticeable effect. After cooling in oil, the test-pieces attained a Brinell hardness of 477, which is the same as that obtained after an oil quench at 850 deg. C. At the end of an hour there was some action at all the temperatures indicated. However, the action is much stronger at 550 deg. C. and the effect is so much the more if, after having held this temperature for some time, one reheats to 650 deg.

These tests are of especial importance in practice and have led to the following conclusions:—

(1) If a casting be quenched by water-spraying, one can cool slowly down to 600 deg. C.

(2) Between 600 and 400 deg. it is necessary to cool specially rapidly, after which cooling can be slowed down. Considerable hardness after quenching will then be obtained, as well as a sorbitic structure without a ferritic network.

(3) If it is considered that quenching by immersion or even by water-spraying is impossible or dangerous, the standard treatment, *i.e.*, quenching and tempering, can be replaced by this new method, which consists in heating the casting up to 850 deg., cooling it at any speed

TABLE I.—*Heat-treatment of Forged and Cast Test-pieces.*

Method of heat-treatment.	Resilience (Mesnager), kg.-m./cm.² Test-pieces.	
	Forged.	Cast.
(1) Oil quenched at 850 deg. C.; reheated 4 hrs. at 660 deg.; cooled in oil..	15.5	14.1
(2) New method:—Heat to 850 deg.; cool any speed to 550 deg. (*e.g.*, in furnace), hold for 3 hrs. at 500 to 580 deg.; reheat to 650 to 680 deg.; air-cool rapidly to 300 deg.	12.5	11.0
(3) Heat to 850 deg.; cool any speed to 550 deg., hold for 3 hrs.; then air-cool rapidly to 300 deg... ..	5.9	5.3
(4) Same procedure as 2, but cooled very slowly from 650 to 680 deg.	2.0	1.1
(5) Same procedure as 1, but cooled very slowly after reheating	1.7	0.7

down to 550 deg., holding at this temperature for 3 hours, and reheating afresh to 650 to 680 deg. for an hour and then, after having removed the casting from the furnace, cooling as quickly as possible down to 300 deg.

The mechanical properties thus obtained will not be any weaker than those secured after orthodox hardening and tempering. The tensile strength is the same, the yield point falls by 9.5 tons per sq. in., while the resilience is reduced only by 2 to 3 kg.-m. per sq. cm.

This method of heat-treatment can be carried out very quickly. An increase of the yield point can be secured by applying a higher temperature than 550 deg. and, holding at this temperature for longer than 3 hours, the reheating to 650

TABLE II.—*Results from Various Heat-Treatment Processes.*

Heat-treatment.	Y.P. Tons/ sq. in.	M.S. Tons/ sq. in.	E. Per cent.	R.A. Per cent.
First method.				
Test-piece forged	46.0	54.0	16.0	66.2
,, cast ..	44.8	54.5	15.8	59.0
Second method.				
Test-piece forged	35.9	54.7	15.0	63.6
,, cast ..	34.8	54.6	17.0	66.0

deg. C. will be indispensable just the same. It is well known that it is extremely difficult to get a *high resilience*. The author has found that sound castings possess a resilience very close to that of forged test-pieces after heat-treating in the identical manner. From an examination of the tabulated results (Table I) of the resilience values obtained on the forged test-pieces treated by different methods, it will be seen that the value resulting from the author's process (without quenching) is almost the same as that secured after an oil-quench and reheating followed by rapid cooling in oil.

Table II summarises the results obtained by the application of the heat-treating processes set out in Table I.

It is seen that for comparable mechanical properties, the yield point has lower values even when the resilience is quite satisfactory. After the second method of heat-treatment the structure is no longer sorbitic. A weak ferritic network and poorly-developed pearlite is noticeable. Such a structure is less desirable than the structure of a steel after quenching followed by reheating. It is, however, better than that of a steel cooled very slowly from 850 deg. C. down to room temperature.

It has to be pointed out that the temperatures given in this Paper are valid only for the particular cast under consideration. Obviously, in each individual case an investigation by the method described must be undertaken in order to determine the temperatures at which to operate, these temperatures differing for every cast.

Life of Steel

AMERICAN ESTIMATES

According to the most recent calculations of the American Iron and Steel Institute, the 34,000,000 tons of finished steel produced in the United States in 1936 will have an average life of 33½ years.

Fifty years ago the life of steel products, before rust or obsolescence ended their career of usefulness, was far shorter. In 1886, the total output of the industry—about 2,500,000 tons, consisting principally of rails—had an average life of only about 15 years. This increase of about 120 per cent. in the average length of service of the steel used in U.S.A. has been due to progress made by the steel and allied industries in the various phases of manufacture, fabrication and preservation, and by the development of new uses for steel, such as skyscrapers, pipe lines and others, which last for many years.

During the thirty-year period beginning with 1886 and ending in 1915, the average life of steel in the United States increased about eight years at a nearly constant rate, which was, however, interrupted by the Great War. During the war an enormous amount of steel was exported, and the useful life of this steel, so far as the United States was concerned, ended when it was shipped abroad. Since the war period, however, substantial advances have been made in both the manufacture and use of steel, which have increased its average length of life by more than ten years.

One of the most important factors in lengthening steel's term of useful service has been the development of alloy steels, some of which materially delay, or even postpone indefinitely, attacks by rust, while others are stronger and consequently more durable.

The average life of steel has also been lengthened by the fact that a large percentage of it now goes into construction, where it is protected from the elements by other building materials. Moreover, a considerable quantity is used underground, as in building foundations and pipe lines, where attack by corrosion is generally less severe than in the open air.

Several industries using steel, notably the automobile, furniture and construction industries, have also made important progress in the development of rust-resistant coatings for steel, both decorative and useful. The fact that the average life of the products of such industries has been lengthened, although not necessarily to as many as 33½ years, the average life of all steel products, has helped to add to steel's average life span.

However, refinements in manufacturing processes, and the rigid tests to which steel products are put before leaving the mills, are perhaps the most important of all the factors which have lengthened steel's average term of service. These refinements and tests are a guarantee of higher quality, and therefore of fewer failures when the steel is put into use.—"Steel Facts."

Drainage

AN OUTLINE FOR IRONFOUNDERS

By D. MACINTYRE-KEIR

Of all the industries associated in the preservation of public health that of ironfounding yields precedence to none, yet no industry perhaps suffers to a greater degree from the chaotic condition of the building by-laws and the idiosyncrasies of the officials administering them.

The ironfounding industry is responsible for supplying the means for transporting the water supply from the reservoirs to the individual members of the community, and principally for providing the means for collecting and conveying that water after spoiling, together with the street washings, to the sewage works or final disposal point. The amount of water to be removed, for all practical purposes, is the same as withdrawn from the reservoirs. If the daily allowance is 30 galls. per person, and that is the general figure, the amount daily to be treated at the sewage works, in dry weather, is 30 galls. per head. Sanitary engineers are agreed on that point. They are also in agreement, generally, as to the methods of removal, but in the actual manner of execution their schemes are many and varied. In this they are supported by the varied and various by-laws of multitudinous corporations, and this lack of uniformity has its repercussions on the trade.

That a revision of the building by-laws to meet the needs of changed conditions, and bring them in line with modern sanitary knowledge and requirements is overdue, is admitted by the English and Scottish Sanitary Institute and Association. The London County Council's acceptance of the new B.S.I. standard pipes in place of their own private standard weights has been a great step towards the desired uniformity of productions, and while this must lead to some confusion in the foundries, that will be of a temporary nature. Some time ago Glasgow Corporation set up a committee to consider a revision of their local by-laws and, meantime, certain concessions may be granted on written application. The Ministry of Health has signified its willingness to sanction such amendments as will remedy the present chaotic scheme of things, while the Institute of Plumbers has prepared a minimum schedule of quantities for plumbing installations, but isolated group movements, however admirable their efforts, are slow in gathering the necessary momentum to achieve what, after all, is a national requirement, and unless their amendments are directed towards achieving complete uniformity in local sanitary by-laws the ironfounder's present unhappy position will not be improved. What appears to be required is a Commission to receive evidence on the working of local sanitary laws, to revise the existing model by-laws in the light of modern knowledge, and to advise the Ministry and Scottish Department of Health in giving these effect. The latter has now formulated sets of model by-laws for the guidance of burghs and county councils under their jurisdiction.

The Basic System

Every house or building, no matter what its purpose or design, must have some method of conveying its roof washings to the drain. The conventional means is by employing gutters and rainwater pipes. Before joining the drain the rainwater must be trapped. The discharge from lavatory basins, sinks, baths and tubs, after passing through a trap fixed as close as possible to the fitment, is conveyed to the drain by means of separate pipes, technically termed "waste" pipes, and this discharge must also be trapped (in addition to being trapped at the fitment) before making connection with the main drain. The discharge from water-closets, urinals and slop sinks is also conveyed to the drain by a third pipe, but in this case the discharge is only trapped at the fitment, and therefore its junction is made without impediment. Technically this is the "soil" pipe.

The rainwater pipe, from the nature of its work, must end at the roof eaves, but as the waste pipes and soil pipes also act as ventilating pipes they should be extended full-bore 3 ft. above the eaves and be well removed from any attic window or other opening. It is bad practice to use the rainwater pipe also as a waste stack or use waste pipes for the dual purpose of conveying roof washings and bath and sink discharges to the drain.

In most by-laws there is a clause specifying the size and thickness of pipes to be used. Scottish sanitary engineering students are taught to use 3-in. by $\frac{3}{16}$-in. waste and 4-in. by $\frac{1}{4}$-in. soil pipes on the grounds that the pipe should be a little larger than the entrance to it. Rainwater pipes need not be of the same high standard as is set for soil and waste pipes so long as they keep the walls and foundations dry. Copper rainwater pipes are used extensively in the United States of America and Canada, and in some towns they discharge on the pavement. In New York, for outside work, they may be of sheet metal, but they must connect to the drain by means of a vertical cast-iron pipe extending 5 ft. above the ground. For inside work they may be of cast iron, wrought iron or steel. The medium used for jointing cast-iron rainwater pipes is red lead, a mixture of red lead and boiled linseed oil or of putty, white lead and tallow worked to a stiff paste.

In accordance with the present regulations, the soil pipe is kept separate and distinct from the waste pipe—grouping these pipes together is a recent innovation—but the day is not far distant when the functions of these separate pipes will be performed by one pipe which is known as the "one-pipe" system of drainage to distinguish it from the orthodox dual system.

Drain Pipes Defined

All pipes used for the conveyance of foul water in a house are termed "drain" pipes, but correctly speaking the drain is that underground pipe conveying the discharges from the house to the sewer. No section of the Public Health Act, 1875, has caused more controversy or resulted in more expensive litigation in England than has the definition of a "drain" and a "sewer" in Section 4 of this Act. In law, and in accordance with the House of Lords decisions, a drain is "Any drain of and used for the drainage of one building only." In Dublin the Customs Authorities are particularly strict in their interpretation of these terms. It is better to avoid their use on invoices and order papers altogether and to describe such castings as underground goods. The drain is considered to belong to the house and must be kept in order by the proprietor. A sewer is a drain belonging to the local authority and common to a number of houses. Sewerage is the system of pipes through a town or city, and sewage is the foul water conveyed by the sewer.

Under present regulations the drain must be connected "with the sewer, provided there be one within 100 yards" of the building (Public Health (Scotland) Act, 1897, Section 120) but the drain, generally, must first be disconnected by means of an approved intercepting or disconnecting trap. The retention or abolition of this trap is a point of very bitter contention amongst experts. In 1908 a Departmental Committee was set up to receive evidence on the matter and in their report dated 1912, its retention or abolition was left to the judgment of local authorities. During the evidence it emerged that "Sewer air is incomparably less dangerous than drain air." The "abolitionists" maintain that the retention of this trap in the drainage system prevents a free current of air from circulating through the pipes, that the dip of the trap remains full of the obnoxious matters being hurried off to the sewage works, and that the fewer the traps in the system the better the ventilation by which the risk from harmful gases is greatly minimised. On the other hand the "retentionists" claim that the disconnecting trap is the first line of defence against the germs of water-borne diseases, and of the deleterious gases contained in sewer air. The iron founder has to please both sections.

In the matter of drainage two points which require early consideration are:—(1) What is required? (2) How best can it be carried out?

The object of the drain is the immediate removal of foul water and excretal matters from the house and its precincts, and also to prevent the reflux of foul air into the dwelling. The drain must be absolutely water-tight and its joints should be as good as the pipe itself.

The bore should be perfectly smooth and cylindrical in shape. Junctions should be made at acute angles to lessen retardation of the flow. It should be laid in straight lines and have a definite and uniform fall.

The size of the pipes to be used requires proper consideration. The standard sizes at present in use are 4 by $\frac{3}{8}$ in. and 6 by $\frac{1}{2}$ in. thick, the former for serving ordinary houses and the latter for buildings and other work. There is far too great a variety in the weights specified by corporations. London County Council weight for 4-in. drain pipes 9 ft. long was 157 lbs.; in Liverpool and Newcastle the weight per 9-ft. length drops to 154 lbs., and in Gloucester the by-laws are complied with at 140 lbs. In passing, it might be remarked that the soil pipe specified for work on the outside of buildings in Liverpool is $\frac{3}{8}$ in. thick. The weight per 6-ft. length is about 100 lbs.

Total Duty for a Drain

Some experts maintain that the drain should be not less than 5 in. dia., but an experiment conducted by a Government commission proved that the correct size of pipe for connection to two closets and one bath was 4 in. dia. laid at a fall of 1 in 40. Those who are engaged in the industry know that the number of 5 in. dia. pipes sold is infinitesimal when compared with the sales for those of 4 in. dia. Pipes and fittings of 5 in. dia. should be used for the drainage of tenements and flats, but 4 in. is quite sufficient for an ordinary dwelling. When fixing the size of pipes one does not require to calculate for sewage. Rainfall, however, is a point of very considerable importance. In a house, say, of 15,000 sq. ft., with the average five occupants and a water supply of 30 galls. per head per day, the sewage to be carried off would be 150 galls. per day, but with a rainfall of 1 in. on the 15,000 sq. ft. there would be, in addition, 780 galls. to remove, or over five times the quantity of sewage. The average rainfall in Great Britain is 39 in. The whole rainfall, however, is not taken in calculations.

Fundamentals for Calculation

The pipes used on a drainage scheme should be as small as possible so as to run full and be self-cleansing. If a large pipe is used to carry off a trifling amount of sewage, the pipes will "choke." To ensure a proper flow the drain must have a proper fall. The gradient must be such as will ensure that the fluids will float out the solid matters. If the gradient is too steep the fluids will run off too quickly, leaving the solids behind, and if the gradient be too flat

E2

the drain will tend to become blocked. It must be evident, therefore, that the velocity of matters passing through the pipe depends upon their sectional area and the gradient at which the pipes are laid. These factors affect the hydraulic mean depth (H.M.D.) or hydraulic radius, *i.e.*, the average depth. The greater the H.M.D. the less the frictional resistance.

The original method of finding the necessary fall was to multiply the dia. of the pipes by 10, thus setting the falls for 4-in., 5-in. and 6-in. pipes as 1 in 40, 1 in 50 and 1 in 60 respectively, but in actual practice these falls have proved unsatisfactory. One authority gives the proper falls for 4-in., 5-in. and 6-in. pipes as 1 in 45, 1 in 56 and 1 in 70 respectively, while another's figures are 1 in 60, 1 in 80 and 1 in 100 respectively. The ideal condition for velocity is to have the pipes running nine-tenths full with a rate of travel of 3 ft. per sec. Thus the formula* for calculating velocity reads:—

$$\text{Velocity} = C\sqrt{R\,S}$$

where V = velocity in ft. per sec.
C = a constant.
R = radius in ft.
S = gradient.

C = for 4-in. fireclay, 62.
= „ 6 „ „ 70.

The materials used must be sufficiently strong, to withstand not internal pressures, as there should be no internal pressures on a drain pipe, but the weight and vibration of modern traffic.

Where Clay Drains Fail

The chief materials used in Britain are stoneware, fireclay and iron. There is very little difference between stoneware and fireclay pipes. A first-class fireclay pipe of Scottish manufacture is equal in all respects to a stoneware pipe and is a much superior pipe to that sold in the North of England as fireclay. The standard length for stoneware pipes is 2 ft. Fireclay pipes are 3 ft. long, and the socket of an iron pipe for connecting to stoneware is 6½ in. dia., and for fireclay 5½ in. dia. The depth for both is usually 2 in. Stoneware and fireclay pipes are quite satisfactory for many purposes, but the health of the community should be far too serious a matter to risk to the vagaries of clay pipes. They cannot be depended upon since both the pipe and the joints are rigid and brittle. If not of the first quality the stoneware pipe in addition is apt to be porous and likely to be sweated. The joints are spigot and faucet and are made with Portland cement (¼ cement, ¾ sand) and if this be not proportionately mixed the joints have a tendency to split. To prevent the cement being forced into the bore a strand of hemp is inserted before caulking.

It has already been pointed out that the purpose of a trap is to prevent the highly injurious gases, principally sulphuretted hydrogen, H_2S, which possesses a smell akin to that of rotten eggs, from entering the dwelling, also that stoneware and fireclay pipes are rigid and brittle, and yet, despite the enormous risk (gases will make their escape at the point of least resistance, which, in these days of Macadamised roads, is usually beneath a house) local authorities not only permit such a state of affairs but are themselves the chief culprits, for few of their own housing schemes are otherwise drained. If challenged, the plea of economy is advanced. Clay drains are an uneconomical proposition and one authority on drainage has declared that the difference between an iron drain and a stoneware drain, both laid in accordance with standard regulations, is, approximately, 5 per cent. In any case economies should start after the drain has been laid. The extra cost of good drains can be regained by installing cheaper fittings for some other part of the house. It is only as a last resort that a wise engineer takes a drain under a building, but if conditions compel him to do so the local authority insists that a clay pipe shall be embedded in and covered with 6 in. of cement. The same precautions are unnecessary when an iron pipe is used. No competent engineer will stake his reputation on a clay drain. It cannot be depended upon and for that reason many engineers have given up its use altogether.

* Gilbert Thomson, M.A., F.R.S.E., M.Inst.C.E.

Cast-Iron Drains

Cast-iron drains are superior in every respect to stoneware and fireclay. They are made in longer lengths, are a better and more uniform shape, have fewer joints, and have a better type of joint, which, when properly made, is as good as the pipe itself. They are infinitely stronger, can be properly tested, have a greater variety of complementary fittings all provided with the means of ready accessibility in the event of any mishaps, and which, in such an event, are not destroyed in gaining access to the obstruction.

Iron drain pipes are made in standard 6 ft., 9 ft. and longer lengths. The joints, which are spigot and faucet, are caulked with molten lead run in and, as in the case of clay pipes, a strand of oakum (yarn) in place of hemp is first inserted to prevent the lead from penetrating into the bore, thereby forming a "feather" to which excretal matters would adhere. The following is a reliable guide for calculating the weight of lead required per joint:—

Dia. of pipe.	Weight of lead.
4 in.	3.38 lbs.
5 „	6.0 „
6 „	8.13 „
9 „	13.0 „

The quantity of yarn required may be reckoned as 1¼ ozs. per inch dia. of pipe. In New York the regulation amount of lead for underground work is specified as 12 ozs. per inch dia.

The Influence of Caulking

The influence of the caulking does not extend the full depth of the socket and in high-class work lead-wool is sometimes used. (Burn Bros. (London), Limited, in describing the advantages of their patent "Pam" pipes for soil and waste purposes, limit the influence of the caulking to ⅜ in. deep.) The advantage gained with lead-wool is that each strand is caulked separately. It is rather an expensive type of joint, but it is a thoroughly good one. There is a very bad practice prevalent in the West of Scotland where some plumbers caulk the joint to within one-quarter of an inch from the top of the socket and filling up the space with red lead. All joints should be caulked to the top of socket bead. A well caulked joint requires no adornment.

Vitreous Enamelled Pipes

In high-class work glass enamelled pipes are frequently specified, but where an accurate set-out has not been undertaken and the pipes are to be cut to fit on site the cost of enamelling might well have been saved, for if enamelling be crazed or chipped, as it is likely to be in cutting, its whole purpose is rendered void. Indeed, one expert maintains that "glass enamelling is not worth the extra cost." All short lengths of pipe should have a properly formed bead cast on the spigot end. For many years an indiarubber ring was used for this purpose, but if the ring was not properly adjusted an uneven spigot resulted. An ingenious gadget has now superseded the ring and the cause for complaint has been eradicated. The wrought-iron bead "shrunk on" is also a thing of the past.

For certain work, such as carrying wastes from laboratories, acid-resisting enamelled pipes and fittings are used. It is a fact not generally known that there is a permanent growth on such castings. On an accurate set-out contract it is advisable to have the standard lengths enamelled and the gain calculated and checked before making arrangements to cast shorter lengths.

There is one other kind of enamelling ironfounders are called upon to supply, namely, vitreous enamelling, and in this case edges have to be machined off to ¼ in. or ⅜ in. radius. After fettling and dressing and before passing to coating sheds, all drain pipes should be tested for smoothness of bore, straightness and soundness. Cameron & Roberton, Limited, who, many years ago, perfected a process to ensure a perfectly smooth bored casting subject their drain pipes to a hydraulic test of 150 lbs. per sq. in., and while under that pressure the pipes are soundly rapped with a hand pick hammer of 1½ lbs. weight. For Admiralty, Air Ministry and H.M. Office of Works contracts the pressure is maintained until the inspecting engineer signals his satisfaction. Each pipe is tested separately.

Modern Traffic Vibration

Drain tracks in the vicinity of main roads and railways suffer greatly from vibration. In the ironfounding industry there are certain firms who are definitely progressive in their outlook and are alive to the needs of modern conditions. By the "Meehanite" process at least one firm has doubled the already high tensile strength of their castings, and while the present is not the time for giving actual data, the tensile strength of regular productions can definitely be stated to be 16 tons per sq. in. The severe drop test imposed for India Office contracts can be successfully applied to daily test-bars which are cast attached to the casting and are not separated until the fettling process has been completed. Inspection pipes should be placed at every change of direction or change of gradient in the drainage system, and at all principal junctions with the main drains, and it is usual to enclose these in a brick chamber of 4½-in. brickwork if shallow or 9-in. brickwork if deep, to which access is gained by a cast-iron manhole cover. The building of this special chamber adds considerably to the cost of the scheme, and, unless very serious inconvenience would be caused to road traffic in the event of a stoppage, it is better to omit the brick chamber altogether and mark the position of these inspections on the drainage plan. There is definitely no necessity for a brick chamber with a first-class cast-iron inspection fitting. A brick chamber at the junction to the sewer, however, is still advised.

With regard to the inspection pipe itself, this can be had either with flat cover or with cover shaped to the contour of pipe, fixed with manganese-bronze bolts and nuts or secured by means of a wrought-iron bridle with a gunmetal pinching screw. This latter means of access is the readiest where time is an important factor. Both methods of fastening are equally good, but it is much easier and quicker to release one or two screws than it is to unscrew six or eight bolts and nuts to gain access. In good work the joint is sealed by means of ⅛-in. blanket felt washers dressed with hot tallow. For other work the sealing is a red-lead joint.

Delineation of Branches

There is still much confusion regarding the reading of branches on inspection pipes and the inclinations of inspection bends. The general method now in use is to imagine the spigot end of the straight inspection, cover uppermost, between one's heels and to read the branches exactly as on the observer's body. The branches on the observer's left are left hand, and on the observer's right, right hand. There is also some confusion regarding their exact location when two or more branches appear on each side of the inspection.. The reading above, it will be observed, is arrived at by looking against the

flow of matter passing through the chamber (matter enters at the faucet end and passes out at the spigot), and to be consistent in the methods of reading the branch locations should be read in the same manner and from left to right, so that the reading of a 4-in. inspection with two 4-in. bottom branches (*i.e.*, nearer spigot) opposed at 112½ deg., and two 4-in. top branches (*i.e.*, nearer faucet) opposed at 135 deg. would be one 4-in. by 112½ deg. branch left, one 4-in. by 112½ deg. branch right, one 4-in. by 135 deg. branch left, and one 4-in. by 135 deg. branch right. However, that reading is not general and at the present time it is always better to give a rough sketch with degrees marked against each branch.

The inclination of bent inspections has been settled, more or less, by the B.S.I. readings for bends. Standing again with the spigot between one's heels, cover facing uppermost, the reading is taken as the socket is inclined, but here, too, it is always better to give a sketch.

There is no comparison between a stoneware or fireclay inspection and an iron one. In the case of the former the cover is cemented on and in the event of a stoppage it is much easier and quicker to break the cover than to pick the cement joint. Good plumbers do pick the joint.

Inspection chambers (and the word is used in its proper sense) are sometimes formed of stoneware channel inverts with chamber walls of white glazed bricks. If a stoppage occurs beyond the chamber, the sewage, since it can find no outlet, backs into the chamber which soon assumes the characteristics of a cesspool. The stoppage may continue undiscovered for a long time or until the sewage assumes sufficient head to clear the obstruction by force or the accumulation of gases fractures the pipe or forces the house traps. The purpose of the white glazed brickwork has not been properly explained but perhaps this is to facilitate washing down the walls after the sewage has subsided or been baled out.

Function of Traps

The object of the trap is to prevent gases travelling along the drain, and, at the same time, provide an easy passage for sewage from the house to the drain and from the drain to the sewer. No trap has been designed effectively to perform both functions simultaneously, for, in erecting a barrier against gases there has been a compromise by allowing the dip of the trap to remain full of the obnoxious matters being hurried off to the sewer. The principle of the trap is that gases cannot pass through liquids. The experiments conducted at Anderson College, Glasgow, disproved that when not only gas but typhoid germs contained in bubbles of air and gas were passed. Gases can press down the liquid in the seal of a trap and bubble through. The pressure required on the outlet end of a "P" trap with a 2-in. seal to do that is a little under one-sixth of a lb. per sq. in. A seal of 2 in. in some ranges of patterns would be considered very deep. Traps, however, are quite effective for their purpose and in a properly-designed system with good ventilation and frequent flushing the danger from back pressure should not arise.

Far too many traps are used in plumbing systems and disconnection is carried to excess. For example, in Northern England waste water is discharged into an open cistern head fixed on the outside of the building and usually in close proximity to a window. This head soon becomes coated with foul soapy matter and the smell is most offensive. It cannot give one much pleasure to look out of the windows in that part of the country. The ventilation of rooms, too, must be rather a difficult problem. In the South, before discharging into the gully trap, waste waters must discharge over a grating and be conveyed to the gully by means of an open channel 18 or 24 in. long. Splashing and flooding into the court is a frequent occurrence and the grating soon becomes foul and offensive. This is positively an unhygienic arrangement.

Again, in a range of lavatories it is sometimes found that the basins are trapped off individually, but in place of the discharge being carried off in a pipe the spigot of each trap is extended to reach to within 3 or 4 in. from the floor where it discharges into an open stoneware channel. This arrangement is stupid and the traps superfluous.

The "one-pipe" system of drainage has already been referred to but it might not be inappropriate to repeat here an argument used in its favour by one of its advocates, "It seems illogical to demand that the waste pipe shall be disconnected from the drain and the drain from the sewer, if the authorities persist in placing ventilating manholes at one's front door. Is it not more logical to ventilate both the sewers and the drains through the waste and soil pipes, thereby permitting the foul air to escape at a height where it is not likely to be breathed? Clear away all traps, except R.W., combine the functions of the waste and soil pipes and there will be a thoroughly ventilated sewer and a more efficient, cleaner and shorter drain.

One reads frequently in text-books that the only objection to iron is its liability to corrosion. Pipes coated with Dr. Angus Smith's solution and in the manner prescribed by the British Standards Institution are free from this complaint. All gutters, pipes and fittings should be coated by this process before leaving the foundry. It might be complained that usually these castings are to be painted to harmonize with windows and other woodworks, and if this be light coloured the coating shows through. If coated work is treated with a dressing of "Knotting" (Shellac and methylated spirit) the difficulty will be effectively overcome.

House drainage is looked upon with disdain by many, but a proper understanding of this important subject is a very great asset, particularly in the light castings industry. It is useless to attempt to sell castings unless one has a knowledge of drainage problems, sanitary law, the purpose and function of each pipe and fitting in the drainage scheme or the correct term for each casting, its method of measurement, together with its method of jointing, also there are the advantages of personal production over that of competitors.

Catalogue Received

Special Steel Forgings. A new catalogue, received from Firth-Vickers Stainless Steels, Limited, of Staybrite Works, Sheffield, 9, gives some details of the physical and mechanical properties of "Stayblade Max." The properties of this alloy are 30 to 35 tons yield point, 45 to 55 tons maximum stress, 25 to 35 per cent. elongation and 45 to 60 per cent. reduction of area. Its Brinell hardness is 220 to 270; specific gravity 7.67; thermal conductivity in c.g.s. units, 0.03; electrical resistivity (microhms per centimetre cube), 85, and coefficient of expansion (20 to 600 deg. C.), 0.0000158. We hope our readers will take good notice of these, as several inquiries have been received on account of a rather vague paragraph appearing in the American Press. Foundrymen should not regard forgings as being necessarily a competitive material to castings, as quite often the two blend excellently for the making-up of a complete unit. Thus the greater the knowledge the foundryman possesses of the nature of forgings the better can he co-operate for the production of high-grade engineering products. On these grounds we suggest that our readers should send for this brochure, which well maintains the high level of industrial publicity for which this firm is justly noted.

Rating and Valuation

HOW THE 1937 ACT OPERATES

The Rating and Valuation Act, 1937, is a measure which, although short in length, nevertheless is important in application. It forms what is known as legislation by reference, and is difficult to understand without some knowledge of former law. In order to explain these matters as clearly as possible, it is necessary to refer to the Rating and Valuation Act of 1925. This Act introduced the present system, which provides for new valuations every five years, and it is in connection with the Third Valuation, in respect of which preliminary steps are now being taken by local authorities, that the 1937 Act will operate. To ascertain rateable value, a "gross value" is scheduled in those cases where the landlord pays for repairs, and a "net value" where the tenant pays. On the "gross value" a deduction is allowed, bringing the figures down to a "net value." In both cases the net annual value is the rateable value, *i.e.*, for ordinary properties. Where properties are classified as industrial premises, the rate payments will be made on one-quarter of those rateable figures. The deductions are statutory and were included in the 1925 Act, but were amended by the 1928 Act. The amended scale is, however, time-limited, and without the 1937 Act the 1928 Act scale would automatically lapse, and there would be a reversion to the former scale with lower deductions.

The 1937 Act makes it clear that the scale as amended is to apply for the Third Valuation. This valuation commences for some districts on April 1, 1938, and for other districts on April 1, 1939. The Third Valuation figures will apply for rates payable from these dates, as the case may be, but the scale of deductions must be used by the local authorities for a considerable time before these dates, as the valuation in draft form is usually completed by the autumn preceding the commencing dates of a valuation (*e.g.*, April 1), in order to allow for objections and revisions before the figures actually apply for rates. Hence the necessity for the latest Act to be on the Statute Book at the present time.

By the 1925 Act, also, a local authority is empowered to require a landlord to pay rates in respect of certain properties instead of the tenant, (the owner recovering the rate payments by an inclusive rent from the tenant), and when this power is exercised a compounding allowance must be given. The 1925 Act fixed this allowance at 10 per cent., but this was amended by the 1928 and 1932 Acts. The 1937 Act provides that the compounding allowance for rate payments made between April 1, 1938 (or 1939), to March 31, 1943 (or 1944), must be at least 10 per cent., but may be more at the discretion of the authority. The allowance must not, however, be more than 15 per cent. of the rate payments.

The scale of deductions for the Third Valuation period will be as follows:—If the gross value does not exceed £15 the deduction is 40 per cent. of the gross value; if over £15 but not over £20, £6 plus 30 per cent. of the amount of gross value in excess of £15; if over £20 but not over £40, £7 or 25 per cent., whichever be the greater; if over £40 but not over £100, £10 or 20 per cent., whichever be the greater; if over £100, £20 plus 16⅔ per cent. of the amount of the gross value in excess of £100. The deduction for land (not agricultural land) and buildings is 10 per cent. of the gross value; and for land without buildings 5 per cent. of the gross value.

The new Act applies to all properties outside London, which term includes Greater London. It does not, however, include properties in inner London which are assessed under the Valuation (Metropolis) Act, 1869; the 1928 Act refers to these and lays down a scale of deductions, but this scale is not due to expire until 1941.

Interrelationships of the Properties of Foundry Sands

In a Paper bearing this title, read before the International Foundry Congress in Paris, Prof. Fr. Pisek and B. Holman state that from many tests carried out on forty-eight types of moulding sands, at the Benes Technical Institute at Brno, Czecho-Slovakia, they have determined

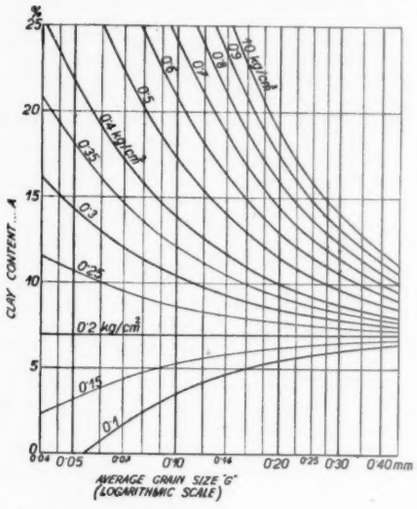


FIG. 1.—NOMOGRAM SHOWING THE RELATIONSHIP BETWEEN THE GRAIN SIZE, CLAY CONTENT AND GREEN BOND STRENGTH.

the following relationships between the properties of these sands in the as-received condition:—(1) Between the cohesion and grain-size and clay content; (2) between the gas-permeability and grain-size and clay content; and (3) between gas-permeability and grain-size and cohesion.

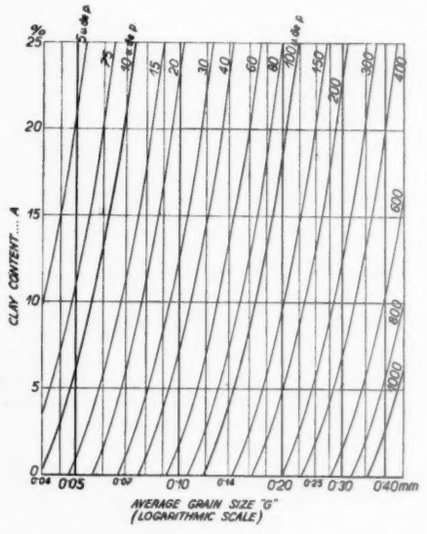


FIG. 2. — NOMOGRAM SHOWING THE RELATIONSHIP BETWEEN THE GRAIN SIZE, CLAY CONTENT AND PERMEABILITY.

The first ratio is expressed by the equation

$$C = AG(0.414\,G + 0.251) - G(2.9\,G + 1.76) + 0.2.$$

The second by

$$P = \frac{(100\,G)^{2\cdot1}}{1.80 + 0.195\,A}$$

The third by

$$P = \frac{(100\,G)\,1.59 + 0.79 \log. 10\,C}{8.3\,C}.$$

To facilitate the practical use of these ratios, the authors have drawn appropriate nomograms (Figs. 1, 2 and 3). For the formulæ, the various letters have the following significance.

C = green sand strength (at maximum moisture content) in kgrms. per sq. cm.
A = clay content, per cent.
G = grain size, mm.
P = A.F.A. permeability unit (at maximum water content).

The ratios deducted and the nomograms allow one not only to calculate the cohesion and probable permeability of sands from the grain size and clay content, but also to classify the

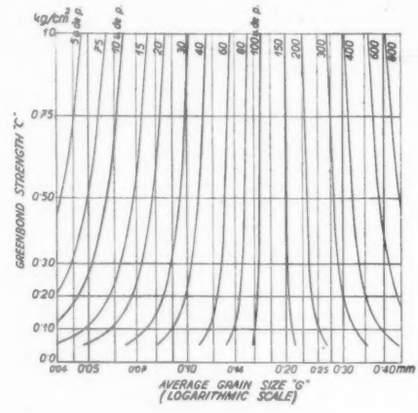


FIG. 3. — NOMOGRAM SHOWING RELATIONSHIP BETWEEN GRAIN SIZE, BOND AND PERMEABILITY OF THE SAND.

sands. The practical use of these relationships is given by the following statement:—

Determination of the cohesion (green bond) and the permeability to gas, knowing the grain size and clay content.

Grain size and clay content are determined by tests, then by the use of the nomogram (Fig. 1) one can determine the probable cohesion (bond), and by Fig. 2 the probable gas permeability. To arrive at these ratios, the authors have undertaken no less than two thousand tests and have carried out large numbers of chemical analyses and granulometric tests.

(*Concluded from next column.*)

It is perhaps unfair to draw comparisons between the relative merits of the different members of this series. If, however, one did indulge in such criticism, it would be to the effect that the author has attempted an almost impossible task in endeavouring to deal adequately with such a tremendous subject in one book. This is really not a criticism of the author who has done his work extremely well, but to point out that his job has been much more difficult than those of the previous authors, who have had the clean cut duties of summarising the data relating to the influence of a specific element on iron.

The reviewer must add a word of criticism of the publishers in that the particular copy which he was unfortunate enough to receive had no less than 16 blank pages. It is assumed that no violent errors appear on the pages which did not allow of criticism. It is scarcely necessary to say that in the reviewer's opinion, these two volumes are worthy companions of their predecessors in this series and are unhesitatingly recommended. The forthcoming additional volumes dealing respectively with chromium, nickel, vanadium, manganese and with cast irons are looked forward to with the keenest interest. The whole series will undoubtedly be a monumental work.

Alloys of Iron Research Monographs

NEW BOOKS REVIEWED BY DR. T. SWINDEN

"The Alloys of Iron and Carbon." Vol. I. Constitution. By Samuel Epstein.

"The Alloys of Iron and Carbon." Vol. II. Properties. By Frank T. Sisco.

(Published by the McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. Price: Vol. 1, 30s., Vol. II, 45s.

These volumes represent further additions to the Alloys of Iron Research Monograph Series which are now well known and widely appreciated. It is natural that these should be regarded as extremely important members of this series. The general method of presentation follows that of the various monographs dealing respectively with alloys of iron and molybdenum, silicon, tungsten, copper and the metal iron itself.

Vol. I by Epstein, dealing with the constitution, refers to the tremendous field that is opened up by the consideration of the iron and carbon alloys, and directs attention to the numerous problems concerning the constitution of such alloys. It is moreover an essential monograph providing a correlation of fundamental data on carbon steels as a base line for evaluating the effects of other alloying elements. The subject is treated in a logical manner, dealing first with the general features of the iron/iron-carbide diagram, following which specially selected features of the diagram are examined in detail. The iron/graphite diagram then receives attention, and the work gradually evolves into a discussion on the changes taking place in iron-carbon alloys during heat-treatment. The work thereby assumes a more practical aspect, always with the underlying fundamental principals well in evidence. Interesting reference is made to various types of defects in so far as they are attributable to the constitution and structural changes in the steel. The latter portion of the book may be regarded as a very useful modern treatise on the whole question of hot manipulation, cold manipulation and heat-treatment of steel, together with the effect of impurities thereon. The reviewer has no hesitation in commending the worthiness of this book.

Vol. II by Sisco is a correlated effort dealing with the properties of iron-carbon alloys. The same general scheme of procedure is followed, and this volume is crammed with detailed information concerning the properties to be obtained from iron-carbon alloys covering cast steel, hot-worked steel, cold-worked steel and heat-treated steel, followed by a very interesting survey of the manufacture and properties of the various types of iron castings.

Any book which attempts to deal with the properties of metals must become a somewhat involved affair, because of the innumerable methods by which the properties are investigated. Thus chapters are found relating to the behaviour of these alloys under repeated stress and at elevated temperatures, together with a section on corrosion and the determination of a large number of miscellaneous physical properties such as are called for from time to time.

It must be regarded as an extremely valuable compendium on the subject, not only for the data to which it draws specific attention, but as in common with all the members of this monograph series, a very detailed bibliography is also included.

(*Concluded in previous column.*)

Recent Studies on the Graphitisation of a Pure White Iron*

By DR. ANTOINE LISSNER and DR. O. KAHL.

A white iron, chemically pure, with 59.92 per cent. of Fe_3C, when cast *in vacuo* does not undergo until 1,145 deg. C.—the point of incipient melting—any alteration by heat-treating in a closed box. Thus it cannot be said that Fe_3C, as a constituent of pure iron is unstable below this temperature. It is thus proposed to impose a correction upon the Fe-C equilibrium diagram. When graphite is to be produced below 1,000 deg. C., it is essential to incorporate in a pure Fe-C alloy some element which will promote the decomposition of the Fe_3C, or to produce external conditions which do this. By comparative dilatometric measurements, the authors have been able to determine that the pure white iron examined, when about 0.5 per cent. of Si is added, starts to become graphitic at 900 deg. C. A decomposition of the Fe_3C of a pure white iron can equally well be obtained, according to Sawamura,[1] by quenching a sample heated up to a pale red heat in water at 20 deg. C. and then re-

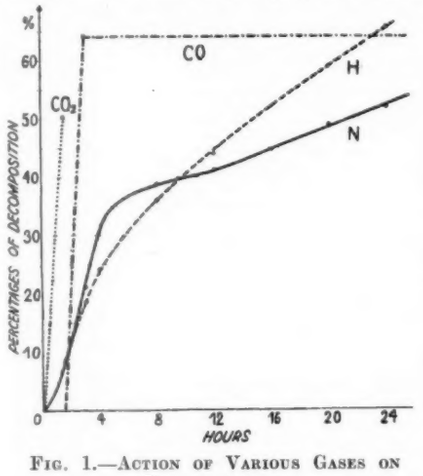


FIG. 1.—ACTION OF VARIOUS GASES ON DECOMPOSITION.

heating. The graphitisation starts, according to dilatometric measurements, at about 890 deg. C.

As this investigator had recourse to heating in currents of gas, graphitisation would be promoted. The nitrogen behaves neutrally, and one can only, when using this, bring about decomposition after repeated heatings and coolings between 1,116 and 1,029 deg. C. By chemical reactions between Fe_3C and H_2, and more so with CO and CO_2, conditions which accelerate decomposition intervene. In pure CO, the theoretical final state of decomposition is reached, within experimental limits, in three hours. The hydrocarbons have only a carburising action, and prevent the decomposition of Fe_3C.

In Fig. 1 the action of each gas plotted against degrees of decomposition, mentioned above, is shown. It illustrates that CO after having reached a certain degree of saturation, produces very rapid decomposition of the Fe_3C, without showing any cementation. The CO_2 exhibits a somewhat similar action, but at the same time it produces a powerful oxidation. The action of H_2 is less, but it obviously makes itself felt when the heating is protracted. If the sample is heated up for more than 10 hours the H_2 permanently accelerates the decomposition of the Fe_3C. The rate of decomposition finally reaches a value double that obtained when operating under a normal nitrogen atmosphere for decomposing Fe_3C. After 24 hours, more carbide has been decomposed than the value corresponding to a degree of saturation of carbon in the crystallised gamma grains of the mixture. This admits of the following explanation: the hydrogen equally attacks the carbon found in the solid solution.

The influence of gases on the decomposition of Fe_3C could only be studied, in the experiments made, within temperature limits which are not used in practice. However, with the results obtained, some quite practical conclusions can be drawn. During the annealing of an iron, the gas content of both it and the surrounding atmosphere plays a part which must not be underrated. In hyper-eutectoid carbon steel, gases rich in CO promote, according to Maurer,[2] a black fracture. A white iron which has been cupola melted in an atmosphere rich in CO, can show a black-heart fracture, after malleablisation in iron ore, due to the heavy formation of graphite, and exhibits poor mechanical properties. Wust and Stotz[3] have dealt with the replacement of iron ore for malleablisation by an appropriate mixture of CO and CO_2. The tensile strength of castings malleablised by gas is, they say, 25 per cent. higher when compared with those malleablised by iron ore.

In a "technically" white iron, of which the conduct of annealing has been specially studied, the decomposition of the Fe_3C is promoted by the presence of CO and CO_2 as related to iron ore malleablisation. For example, this iron malleablised at 1,000 deg. C. with iron ore, has reached a decomposition percentage of 71.38 as against 50.60 when carried out in a neutral atmosphere. Up to now, probably too little attention has been given to this fact. By such an annealing in an appropriate atmosphere, not only decarburisation can be produced, but also graphitisation can be promoted. Taking these observations into account, it should be possible to accelerate the old established European process of malleablisation or, put another way, to develop a quick anneal process.

* Summary of a Paper presented to the International Foundry Congress held in Paris.

[1] H. Sawamura—"Stahl u. Eisen," 50 (1930), 369.

[2] E. Maurer—Krupp, 4 (1923), 119.

[3] F. Wust and R. Stotz, "Ferrum," (1916-1917), 33.

Book Review

Magnesium-Legierungen. Patentsammlung. By A. Gruetzner, with the co-operation of G. Apel and G. Goetze. Published by Verlag Chemie, G.m.b.H., 3, Corneliusstrasse, Berlin, W.35. (Reduced price for abroad, .Rmk. 15.)

This volume gives the compositions of all magnesium alloys disclosed in German, English, French, Austrian, Swiss and United States Patent Specifications published during the period 1909 to the end of December, 1936. Although published throughout in the German language, the volume is exceedingly easy to understand, and it could indeed be used by the average person without any knowledge of German. The composition of approximately 2,900 different magnesium alloys are given, together with particulars of the patent specifications in which they are disclosed and a brief indication of their properties and uses.

This volume will doubtless be very valuable to patent agents drawing up specifications concerning magnesium alloys or engaged in litigation concerning such patents. It should, however, be still more valuable to any foundry handling magnesium alloys. In so far as magnesium alloys are concerned, there is probably more information to be found in patent specifications than in all the other technical literature put together, and this present volume is a complete index to that huge mass of information.

It should be particularly noted that all the compositions given have not been actually patented, but may only have been disclosed in the text of a specification. Also, many of the patents mentioned have, of course, expired. The only adverse criticism which may be ventured is that it is a pity that such a valuable reference book has been printed on such poor paper.

J. F. K.

Influence of Solidification Conditions on Aluminium Castings*

By DR. R. IRMANN.

Several examples taken on sand- and chill-cast castings show the influence of the conditions of solidification. The influence of a large grain size structure which corresponds to a slow cooling rate ought not to be over-emphasised, for this factor has only a deleterious influence on the mechanical properties, so long as it is associated with the separation and agglomeration of the constituents which crystallise later. These phenomena are easily understood by an examination of an heat-treated Al-Cu-Mg alloy. One should always remember that a large grain size is deleterious from the endurance limit point of view, because the fatigue fractures are intercrystalline. The tests made up to now have certainly not proved this. In every case, a large grain size should be avoided, and this structure should not appear either when removing runners or carrying out anodic oxidation.

A method of avoiding large grain size is by the addition of titanium or cerium. Certain alloys of the Al-Mg-Zn_2 type have wide application. To reconcile the constructional and foundry points of view, the example of an angle bracket clearly illustrates the inconveniences due to acute angles and thick walls and the advantage to be derived from the use of chills.

Beyond the study of the influence of rate of cooling in the liquid state, that is, rate of solidification, an example was given showing that it is also profitable to study the rate of cooling of a metal to the solid state, and attention has been drawn to the question of runners and risers for quantity production, and to the time to allow before stripping the mould. The nature of the alloy naturally plays an important part on these factors.

* Summary of a Paper presented to the International Foundry Congress in Paris.

Determining Properties by Brinell Hardness

In a Paper, "Relations Between Hardness and Other Properties of Cast Iron," presented to the International Foundry Congress, in Paris, by DR. G. MEYERSBURG, it is stated that if it is desired to obtain but a general notion of the tensile strength, machinability and wear resisting properties of an iron casting, an approximation can be deduced from the hardness. The best property to approximate is that of machinability, if due thought is given to the incidence of hardness irregularities, but it is difficult to predict definitely the tensile and wear resisting values. To effect this, consideration must be given to the aspect of the structure. Thus, difficult hardness specifications give no real guarantee that the tensile strength and wear-resisting properties will be of the same order and should never be allowed to cause troublesome differences between supplier and user.

Strength of Tin-Base Bearing Alloys

The International Tin Research and Development Council, of Manfield House, 378, Strand, London, W.C.2, has issued a report of researches by C. E. Homer, B.Sc., Ph.D., and H. Plummer, into the "Mechanical Properties of Some White Bearing Metals and Other Tin-Base Alloys at Various Temperatures." This Paper, Technical Publication, Series A, No. 57, gives data about tensile and Brinell tests on typical tin-base bearing metals and on alloys made by adding cadmium. Up to 3 per cent. addition of cadmium improves the strength and hardness, but above this amount there is a loss of ductility. Alloys of tin, copper and cadmium without antimony do not appear to have any outstanding properties. Copies may be obtained free of charge from the Secretary.

A Method and Apparatus for Studying the Physical Properties of Vitreous Enamels on Steel*

By J. E. ROSENBERG and A. LANGERMAN

Introduction

The physical properties of vitreous enamels have been studied to the extent that it is now possible to calculate the value of some of them from the chemical composition of the frit. This has been of considerable help to the manufacturer of enamels and has enabled him to vary his composition, maintaining certain physical properties without the necessity of making measurements on his products. While these physical constants were known, there has been little attempt to apply them to the practical problems of enamelling. To the industry, an enamel does or does not suit the job properly, although it is fairly well established that enamels having physical properties between certain limits work best. The pioneer studies in this field were made by Mayer and Havas.[1] They accurately measured the expansion of ground-coat and cover-coat enamels as well as iron and showed that the coefficients of expansion of the three are approximately as follow:—

For iron	.. .. ..	$384–420 \times 10^{-7}$
„ ground coat	.. ..	$245–289 \times 10^{-7}$
„ cover coat	.. ..	$327–348 \times 10^{-7}$

These are the cubic coefficients and, for practical considerations, the linear coefficients are one-third of these values. These measurements were made between 0 and 100 deg. C. and are reasonably reliable. The values for steel, however, are closer to 340 to 360 $\times 10^{-7}$, while the values for the enamels would present the limits of those in use to-day.

More recently, exact measurements have been made on the expansion of enamel and iron at enamelling temperatures. The coefficient of expansion of both the iron and enamel increases with temperature. For instance, Andrews and Howe[2] give a coefficient of expansion of 334 $\times$ 10^{-7} for an enamel at between 18 and 102 deg. C., while for the same enamel between 20 and 475 deg. C., the average coefficient value is 445 $\times$ 10^{-7}. For iron,[3] the value between 0 and 100 deg. C. is 363 $\times 10^{-7}$, while between 0 and 500 deg. C. it is 426 $\times$ 10^{-7}. Andrews describes the various methods used for measuring the coefficient of expansion and gives references to the most important articles in his book.[4] In a study of white ground coats, it was found necessary to measure the expansion of enamels.[5]

The authors have devised a method for estimating the coefficient of expansion as well as other physical properties of the enamel which can be carried out with the usual equipment found in any enamelling shop or laboratory in a short time. Simply stated, the method consists of applying and firing a coat of the test enamel to a strip of steel formed into the shape of a split ring. The enamel is applied on one side only of the ring and is held rigid during the firing. After firing and cooling, it is found that the ring exerts a force to increase or decrease its diameter, depending on whether the enamel is applied on the inside or the outside. If the enamel is applied outside, the ring exerts a force which decreases its diameter, while if applied inside it exerts a force to increase its diameter. The value of this force is a measure of the difference between the contraction of the steel and the enamel during the cooling of the fired piece. This method has the advantage of measuring the properties of the enamel as they are applied and fired on the metal, while the usual methods measure only the properties of the glass itself. Andrews,[6] however, has presented data showing that the coefficient of expansion is only slightly affected by the usual mill additions.

Procedure

A steel ring was formed, 2.7 in. dia., from a strip 1 by 8 in., leaving a $\frac{1}{2}$-in. gap in the circle. Holes $\frac{1}{16}$ in. dia. were symmetrically placed $\frac{1}{4}$ in. from the ends of the strip. These rings, made usually of 20-gauge steel, were formed in a die to ensure uniformity. They were cleaned and pickled by the usual method and covered with enamel, usually by spraying. They were then dried and placed on a firing tool, previously heated, which maintained the ends of the ring at a distance of approximately $\frac{1}{2}$ in. during the firing and cooling.

FIG. 1.—METHOD OF HOLDING RING WHEN FIRING ENAMEL.

Fig. 1 shows the ring on the firing tool. The rings were fired in a furnace at the proper temperature, for ground coat usually 5 mins. at 899 deg. C. and for cover coat about 771 deg. C. for $2\frac{1}{2}$ mins. When the ring and the tool had cooled, the ring was removed from the tool and measurements on it were made. Applying ground-coat enamel on the outside of the ring only, the resulting openings were as follow:

	Ins.
Original opening	0.50
14 grms. per sq. ft.	0.38
18 grms. per sq. ft.	0.33
20 grms. per sq. ft.	0.31
30 grms. per sq. ft.	0.20

The results given above indicate that the compression of the ring increases with the thickness of application of the enamel, and results on heavier and lighter gauge steels indicate that the gap is inversely proportional to the thickness of the steel, that is, lighter gauge steel is more compressed than heavier gauge. Thus far it would seem that this method might be used to compare the coefficients of expansion of vitreous enamel, but this is not the case because the contraction will depend on the coefficients of expansion of the enamel and the steel, the softening point of the enamel, Young's modulus of the enamel and steel, and the thickness of the steel.

Theoretical

While this discussion is not concerned with numerical values, it is well to bear in mind that the steel has, in general, a coefficient of expansion greater than enamel. Consider strips of glass and metal, both of the same length, at a temperature, T_1, at which the enamel solidified. Cooling both to room temperature, T_2, they contract at different rates, so that the lengths, if each were allowed to contract freely, would be for the steel

$$L_t(1 - \alpha_s \Delta T)$$

and for the enamel

$$L_t(1 - \alpha_e \Delta T).$$

Where L_t = length at glass softening temperature
α_s and α_e = av. coefficients of the steel and glass
$\Delta T = (T_1 - T_2)$.

The coefficient of expansion, α, is not a constant during the range of temperature between the softening point and the room temperature. In reality,

$$\alpha = \frac{dL}{dt} \cdot \frac{1}{L}.$$

The length of a strip, L, may be represented as a function of temperature.

$$L_t = L_0(1 - at - bt^2 - ct^3)$$

$$\frac{dL_t}{dT} = L_0(a - 2bt - 3ct^2)$$

$$\Delta L = \int_{T_2}^{T_1} L_0(a - 2bt - 3ct^2)dt$$

$$\alpha = \frac{\Delta L}{T_1 - T_2} = \frac{\Delta L}{\Delta T},$$

which is the average coefficient of expansion between the softening point and room temperature.

Since the glass and the metal stick together, the final length of both will have to be the same at the interface so that the steel, which tends to contract more, will be prevented from so doing by the enamel and will therefore be under tension; the glass will be contracted more by the steel and will therefore be under compression (Fig. 2).

Let $\triangle S$ and $\triangle E$ be the change in length of the steel and the enamel due to mutual forces of

* Paper presented to the American Ceramic Society.

1 M. Mayer and B. Havas, "Sprechsaal," **42**, 497, 1909.

2 A. I. Andrews and E. E. Howe, "Effect of Fluorides on White Sheet-Iron Ground-Coat Enamels," "Jour. Amer. Ceram. Soc.," **17** [10], 289, 1934.

3 International Critical Tables, Vol. 2, p. 460.

4 A. I. Andrews, "Enamels." Twin City Printing Company, Champaign, Ill., 1935.

5 At the suggestion of N. W. Taylor, of Pennsylvania State College, the authors adapted the ring method of H. G. Schurecht and G. R. Pole, "Jour. Amer. Ceram. Soc.," **13** [6], 369–75, 1930.

6 At the Annual Meeting of the American Ceramic Society, Buffalo, N.Y., February, 1935.

compression and tension. The final lengths of the glass and the enamel which will be equal are

$$L_f(1 - \alpha_s\Delta T) + \Delta S = L_f(1 - \alpha_e\Delta T) - \Delta E$$
$$\Delta S + \Delta E = L_f(\alpha_s - \alpha_e)\,\Delta T.$$

Assuming that the materials are elastic within these limits, then

$$\Delta S = \left[\frac{FL}{EA}\right]_s \text{ and } \Delta E = \left[\frac{FL}{AE}\right]_e.$$

Where F = elastic force
L = length of strip
E = Young's modulus
A = cross-sectional area.

F and L have like values for steel and enamel; E and A have different values.

Substituting these in the equation for both the enamel and the steel, the following equation results:—

$$\left[\frac{FL}{EA}\right]_s + \left[\frac{FL}{EA}\right]_e = L(\alpha_s - \alpha_e)\,\Delta T.$$

Since the forces are equal,

$$F\left[\left(\frac{1}{EA}\right)_s + \left(\frac{1}{EA}\right)_e\right] = (\alpha_s - \alpha_e)\,\Delta T.$$

$$F = (\alpha_s - \alpha_e)\,\Delta T \cdot \frac{(AE)_e \cdot (AE)_s}{(AE)_e + (AE)_s}.$$

This equation indicates that the force will increase in the same way with increasing thickness of both steel and enamel. By using steel of a

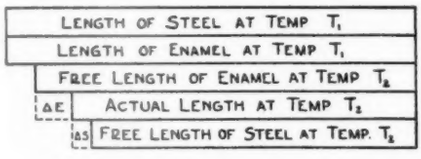

LENGTH OF STEEL AT TEMP T1
LENGTH OF ENAMEL AT TEMP T1
FREE LENGTH OF ENAMEL AT TEMP T2
ΔE
ACTUAL LENGTH AT TEMP T2
ΔS
FREE LENGTH OF STEEL AT TEMP. T2

FIG. 2.—STRAINS IN STEEL ENAMEL.

T_1 = temperature in oven.
T_2 = room temperature.
ΔE = change in enamel length due to stress.
ΔS = change in steel length due to stress.

definite thickness and by varying the thickness of the glass, one can differentiate and determine the change of the force, F, with the change of thickness, and obtain

$$\frac{dF}{d(AE)_e} = (\alpha_s - \alpha_e)\,\Delta T\,\frac{(AE)_s^2}{[(AE)_s + (AE)_e]^2}.$$

If the product of (AE) for enamel is small compared to that for steel, which is not an unreasonable assumption for thin coats of enamel, then the equation reduces to

$$\frac{dF}{d(AE)_e} = (\alpha_s - \alpha_e)\,\Delta T.$$

This means that the slope of the line showing the relationship between the force and the thickness of application is numerically equal to the difference between the coefficients of expansion of the steel and the glass multiplied by the difference between the softening point and room temperature. This is an important constant and is a property of the enamel which will determine the stresses produced when it is fired on steel. It has no physical dimensions and is in fact

$$\frac{\Delta L}{L},$$

or the fractional change in length between the steel and the glass when they are cooled from the softening point to room temperature.

Owing to the fact that the forces are internal, it is difficult to measure them on a straight strip of steel. It is, however, relatively simple to use a steel strip formed into a circle and to measure the tensile force which acts to close the circle. This force, while not directly equal to the above, nevertheless is an indication of that force. To determine this force, the fired ring was suspended and the upper end held, while a weight was applied to the lower end until the gap was restored to its original ½ in. (Fig. 3). This force represents the mechanical stress when the piece is fired and cooled without allowing it to close the gap. Below are given some data on the force required to restore the gap for various applications.

TABLE I.—*Tensile Force on Fired Ring.*

Application (A) (grms. per sq. ft.). Force (F) (grms. weight).

Ground coat.		White ground cobalt coating.		White ground coat on ground coat.	
A.	F.	A.	F.	A.	F.
14.0	44.2	33.5	47.0	31.0	138.3
14.0	36.9	35.9	56.0	31.02	128.3
18.0	60.6	39.5	116.0	40.7	173.3
21.2	81.0	42.8	95.0	38.3	168.3
20.5	73.5	52.5	198.0	50.5	212.4
28.4	133.5	60.4	208.0	48.85	212.3
29.7	143.5	60.6	230.2	53.5	272.6
31.5	128.1	64.6	255.2	52.5	233.3
20.6	86.7	73.5	269.2	68.4	319.7
—	—	73.6	295.9	65.5	325.3

Fig. 4 represents graphically the above data. When an equal weight of enamel is applied on both sides of the ring, the ring maintains its original position within very small limits and little or no force is required to restore it to the original gap of ½ in. If, however, the enamel is applied on the inside, then the ring, after firing, expands, and the force required to open the gap is, within the limits of the authors' measurements, equal to the force required to close the ring with the same application on the outside. Extrapolating the curve (Fig. 4) for the application against the force required to close it, it is found that the force will be zero when the application is approximately 25 grms. per sq. ft., while in the case of the same enamel applied on the ground coat, the curve passes through the origin. It is well known that a part of the ground coat reacts with the enamel and penetrates into the steel, so that of the total enamel applied only a certain portion is left to exert its elastic force. In the case of the white ground coat applied on ground coat, where there is no such reaction, one finds that the force is, for small applications, proportional to the application.

The results with the white ground coat are substantiated by the reflectivity measurements, and it is found that, with an application of about 60 grms. per sq. ft., the reflectivity is approximately equivalent to 30 to 35 grms. per sq. ft.

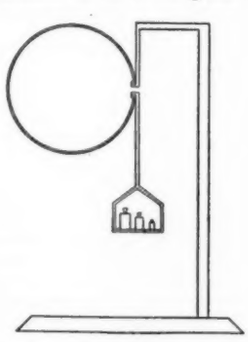


FIG. 3.—METHOD OF STRESSING RING.

In other words, 25 to 30 grms. per sq. ft. of the white ground coat have reacted with the steel and no longer are effective in producing a mechanical stress or reflectance. This, of course, will depend on the enamel and the degree of penetration into the steel.

This entire discussion has been based on the assumption that the glass and the steel behave as elastic bodies and that the forces applied never exceed the elastic limit. In order to test this assumption in part at least, the rings which had been fired with the enamel were placed in the furnace and the temperature raised gradually with the idea of following the change that takes place as the ring is heated. It was found that the ring which was closed expanded when heated gradually, until at a temperature of 260 deg. C. to 315 deg. C. the gap was approximately ½ in. When heated higher, the gap increased and reached a maximum apparently at 343 deg. C. Between 510 deg. C. and 537 deg. C., the gap again came to its original ½ in. When this heated ring was allowed to cool to room temperature, the gap returned again to the original opening, which in this particular sample was about $\frac{1}{16}$ in.

In the case of the ring which was enamelled on the inside with an original opening of $\frac{5}{8}$ in. at 287 deg. C., the gap closed to about ½ in., and then closed further on heating. At 537 deg. C., the gap was ¼ in. On cooling, the gap reached a minimum opening of about $\frac{1}{16}$ in. at 454 deg. C. and, when cooled to room temperature, the gap resumed its original opening.

The behaviour is extremely interesting, particularly in view of the measurements of the

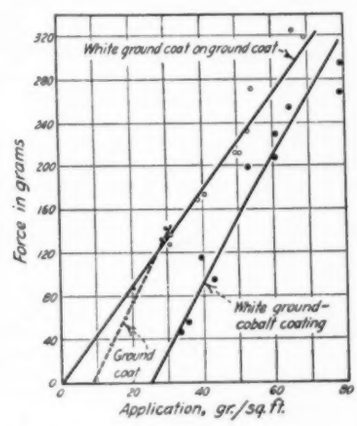


FIG. 4.—TENSILE FORCE ON FIRED RING.

expansion of enamel and steel made by Dietzel and Meures.[7] While the expansion of enamel is greater than that of steel at room temperature, when the temperature is raised the point is reached where the curves cross, and after that the expansion of the steel is greater than that of the enamel. The integral expansions, however, of the steel and the enamel become equal at some temperature above that at which their coefficients of expansion are equal.

It is planned to study more carefully the behaviour of a fired ring on heating and cooling.[8] The slight difference between the behaviour of the ring enamelled on the inside and that enamelled on the outside is due, in the case of the ring enamelled on the outside, to the fact that the force to expand the enamel is exerted by the steel, while in the case of the ring enamelled on the inside the force of expansion is probably exerted by the enamel.

In the enamelling in which ground coat is applied on both sides of the steel, the strains and stresses are wholly internal, and the resultant force is usually zero, unless, of course, the application on one side is considerably greater than on the other. If, however, a vessel is enamelled in which the one side is not coated

7 A. Dietzel and K. Meures, "Explaining Expansion in Sheet-Iron Enamel," "Sprechsaal," **66** [44], 746–52 (1933).

8 The authors were not aware at the time of the presentation of this Paper of the work under way on the same problem at the Bureau of Standards under the direction of W. N. Harrison. They have since learned that this research was authorized by the Director of the Bureau in November, 1932, and that a published account of the study appeared in "Technical News Bulletin" for July, 1933. The preliminary results were presented at the 1934 Meeting of the American Ceramic Society. This work at the Bureau of Standards is being continued.

with ground coat (*e.g.*, the evaporator used for refrigerators), it will no doubt present difficulties. Fortunately, these vessels are now made of steel of such a gauge that the force exerted by the enamel on one side is not sufficient to distort and cause crazing and similar defects.

These troubles are most likely to occur on concave rather than convex surfaces. On convex surfaces, a further stress will produce only a slight change in the radius of curvature. When a cover-coat enamel is applied over the ground coat and on one side, the tendency toward warping will be great, particularly on the application of a second cover coat, because on the application of the first cover coat the forces are set up only after the cover-coat enamel has been fired and is cooling, and any mechanical strain induced may cause a warping of the ware but will not cause any cracking of the enamel. On the application of the second cover coat, however, warping will take place when the ware is heated because of the unbalanced effect of the fused cover coats. This is often overcome by the application of enamel on the back of the ware. It is well to note that the crazing that is usually seen, occurs in the unfired bisque rather than in the fired enamel, and the difficulties arising out of the application of a number of coats of enamel are more than in proportion to the number of coats, owing to this unequal stress on the steel.

The authors have not discussed the method of calculating Young's modulus or the coefficient of expansion, but they believe that with this method both of these values for steel and enamel may be calculated. It is planned to continue this work along these lines.

Relationship of Sheet Steel Thickness and Yield Value to Ground Coat Adherence*

By G. SIROVY and E. P. CZOLGOS

Introduction

Chipping constitutes one of the most common defects that occur in porcelain enamel industries. As an initial step into the investigation of this, the authors chose to study the failure of the ground coat enamel under impact and tensile stresses set up by mechanical external forces, affecting both the enamel and steel phases. Dr. Andrews, of the University of Illinois, has demonstrated that ground coat enamel would fail under tensile stress if the steel was elongated beyond its elastic limit. The object of this study was to make an examination of the relation of that reaction to chipping in ground coat enamelled sheet steel gauges most commonly used in commercial practice.

TABLE I.—*Data of Elongation through Tensile Stress Tests.*

Steel gauge.	Steel thickness. In.	Stresses at yield value.		Stresses at enamel fracture.		Cross-section area.
		Stress. Lbs.	Stress. Lbs. per sq. in.	Stress. Lbs.	Stress. Lbs. per sq. in.	
14	0.0743	2,580*	28,631	2,810*	31,153	0.0902
16	0.0598	2,040*	27,775	2,190*	29,796	0.0735
18	0.0469	1,733*	28,999	1,897*	31,669	0.0599
20	0.0376	1,363*	27,816	1,560*	31,837	0.0490
22	0.0331	1,290*	29,054	1,413*	31,824	0.0440
24	0.0269	980*	27,300	1,153*	32,116	0.0359
			28,263†		31,399†	
Elongation, ins.						0.0625
Elongation, per cent.						3.125

* Average of three tests. † Grand average.

This investigation consisted of subjecting ground coat enamelled sheet steel samples of 14, 16, 18, 20, 22, and 24 gauge to the following tests:—

(1) Elongation through tensile stresses, by means of an Olsen tensile strength testing machine. The following results were noted:—

(*a*) Yield value in lbs. per sq. in. of the ground coat enamelled samples of each gauge, (*b*) stress in lbs. per sq. in. when the enamel fractured; (*c*) comparative type of enamel fracture; and (*d*) percentage of elongation at time of the enamel fracture.

(2) Crushing by impact, without deformation of the steel, by means of a drop hammer bond testing machine. The following results were noted:—

(*a*) Type of enamel fracture; and (*b*) comparative degree of enamel fracture.

(3) Crushing by impact, with deformation of the steel, by means of a drop hammer bond testing machine. The following results were noted:—

(*a*) Depth of steel indentation of samples of each gauge; and (*b*) comparative degree and type of fracture of the enamelled phases.

The results of each of these tests were noted and conclusions drawn therefrom.

Description of Test Samples

The type of sample used for all three tests was 2 in. by 12 in. in size, with a concave narrowing of the centre width to 1⅛ in., for an inner length of 2 in., the reduction starting 3¼ in. from each end. Ground coat enamel was applied to both faces of the samples, by dipping in a ground coat, the consistency of which was set so as to drain to 1¼ ozs. dry enamel per sq. ft. Before being burned, the enamel was brushed away ½ in. from each edge so as to remove any drain beads, and 1 in. from each end so as to fit properly the tensile strength testing machine.

All samples of similar gauge were burned together in an oil-fired box-type furnace at 850 to 860 deg. C. until the ground coat was mature. The average thickness of enamel coat was 0.0033 in., measured by means of a "G.E." magnetic enamel thickness gauge.

Testing Machines

The machines used for the tests were:—(1) Olsen tensile strength testing machine, capable of exerting a maximum tensile stress of 10,000 lbs., with the accuracy of the stresses being indicated within 10 lbs.; and (2) impact bond testing machine of the drop hammer type, capable of exerting a stress of 9.52 ft.-lbs. at impact.

Description of Tests

Elongation through Tensile Stresses.—The samples were elongated at the rate of 0.05 in. per min., to the elastic limit of the steel, and on to fracture of the enamel surface. The actual stress in pounds was recorded at the elastic limit of the steel and at the point where the enamel fractured. The elongation of a 2-in. gauge length at the centre of the sample was measured. From these data, the percentage of elongation, the tensile strength of the steel in lbs. per sq. in., and the stress in lbs. per sq. in. at the time of enamel fracture was calculated.

TABLE II.—*Influence of Gauge on Tensile Stress necessary to Fracture Enamel.*

Gauge.	Stress. Lbs. per sq. in. at yield value.	Stress. Lbs. per sq. in. at enamel fracture.
14	28,631	31,153
16	27,775	29,796
18	28,999	31,669
20	27,816	31,837
22	29,054	31,824
24	27,300	32,116
Average ..	28,263	31,399

Impact Without Deformation of the Steel.—This test was performed on each sample by means of the impact bond testing machine, using a closed anvil and ball-point hammer. One end of each sample was subjected to an impact force of 9.52 ft.-lbs. The degree and comparative type of enamel fracture were noted.

Crushing by Impact with Deformation of the Steel.—The impact bond testing machine, using the open anvil, whose area was 0.3547 sq. in., was used for this test. One end of each sample was subjected to an impact force of 9.52 ft.-lbs. The depth of steel indentation and the comparative degree and type of enamel fracture were noted.

Results of Tests

Elongation through Tensile Stresses.—The important result obtained from this test revealed that ground coat fracture or chipping did not occur until the steel was elongated beyond its elastic limit on all gauges. The fractures occurred as short cracks, parallel to each other and at right angles to the lines of stress. They were first noted in the glass phase and then immediately after in the bond phase. The percentage of elongation at the point of fracture was the same for all gauges, and was equal to 3.125 per cent.

Impact without Deformation of the Steel.—Equal degree of fracture occurred in all gauges. The type of fracture was a shattering one, for the most part, of the glass phase of the ground coat, over an area of about 0.0284 sq. in. No pronounced fracture of the bond phase or deformation of the steel shape could be detected by eye examination.

Impact with Deformation of Steel

Deformation occurred in all gauges. The maximum amount occurred in the thinnest gauge, the No. 24, decreasing to the least amount in the thickest gauge, the No. 14. The minimum amount of total fracture area occurred in the thickest gauge, the No. 14, increasing in extent in the No. 16 gauge, with the Nos. 18, 20, 22 and 24 being equal in extent. Fracture of the glass phase and slight fracture of the bond occurred to an equal degree in the outer circumferential impact areas in all gauges.

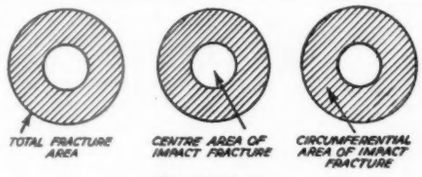
The maximum amount of fracture of the glass and the bond occurred in the centre of the impact area of the thickest gauge, decreasing in extent to the thinnest gauge, where no fracture of either phase occurred in that area, due to the fact that in the case where the gauge is so thin

* Paper presented to the American Ceramic Society.

as to offer very little resistance, in the centre zone of impact there is a punch action, with the fracture taking place for the most part along the circumferential area where the deformation has taken place. Unless this be taken in consideration, the result may be misleading.

TABLE III.—*Data on Impact with Deformation of Steel.*

Gauge.	Total thickness. In.	Depth of steel indentation. In.	Total fracture area. Sq. in.	Centre area of fracture. Sq. in.	Degree of fracture of C.A.	Circumferential area of fracture. Sq. in.	Degree of fracture of circum. area.
14	0.0809	0.024	0.209	0.049	Glass phase / Bond phase	0.160	Glass phase
16	0.0664	0.032	0.338	0.049	Glass phase / Slight / Bond phase	0.289	,, ,,
18	0.0535	0.044	0.355	0.049	Glass phase / Slight / Bond phase	0.366	,, ,,
20	0.0442	0.045	0.355	0.085	Slight / Glass phase	0.271	,, ,,
22	0.0397	0.048	0.355	0.085	Slight / Glass phase	0.271	,, ,,
24	0.0335	0.050	0.355	0.111	None	0.245	,, ,,



Conclusions

The results of these tests indicate that:—

(1) Ground coat enamel fractures, due to tensile stresses alone, do not occur until the elastic limit of the steel is exceeded. Of course, the actual stress required to exceed the elastic limit of the steel increases with the thickness of the steel gauge, because of the increase in cross-sectional area available to absorb the stresses.

(2) Ground coat enamel fractures, due to equal impact stresses, are comparatively equal in all steel thicknesses, provided the steel is reinforced so as to prevent deformation of its shape.

(3) Ground coat fractures, due to equal impact stresses, decrease in extent with increase in steel thickness where the steel is allowed to be deformed by the impact stresses because of increase of reinforcement with increase of steel thickness.

Acknowledgment

In closing, the authors wish to acknowledge the interest, suggestions and help of Mr. E. R. Mills, of the Ingersoll Steel & Disc Company, Mr. F. Porter, of the Inland Steel Company, and Mr. Holscher, of the Edison Electric Company, who have helped to make this investigation possible.

Black Specks in Cover Coat Enamels*

By JAMES D. TETRICK

Tracing the Origin of Black Specks

Given a case of black specks the enameller must quickly trace it to its sources and eliminate the cause. The possible origin of the trouble may usually be determined by a close visual inspection. It is usually possible to determine whether the origin is in the ground coat, foreign material in the enamel slip or introduced during the spraying operation, or from dirt alighting on the surface of the ware. A most convenient and inexpensive instrument for helping in this inspection is a small microscope capable of magnifying 40 or 50 diameters. A more desirable although much more expensive instrument is the long focus, binocular type microscope.

If it is believed that the enamel slip is contaminated, a convenient and easy way of checking up is gently to wash one pint of the enamel slip through a 200-mesh screen. Examination of the residue while still wet will quickly deny or affirm this belief. Drying the residue and then turning it over a few times on a piece of white paper will permit any dirt specks present to be segregated for examination under the microscope. A small horseshoe magnet is suitable for testing the particles to determine if they are magnetic iron. If the black speck condition is not due to the enamel slip, then a careful observation of shop practice and conditions must be made. Specks which tend to be imbedded in the fired enamel, if not due to ground coat conditions, are almost certain to be due to dirty enamel slip or to an accumulation of dirt in the enamel coating during the spraying operation.

Specks which lay on the surface of the enamel are obviously acquired after the spraying operation. Light stoning of the specks in question assists in determining how deeply they are imbedded.

Mill Room Sources of Black Specks

For the purpose of this Paper it will be assumed that all materials charged to the mills are free from foreign elements which would cause black specking, although in any case where the specking has been traced to the enamel slip all materials entering the mill must be suspected. Clay is usually the worst offender. The condition of the mills is of utmost importance in the production of clean enamel slip. The mills should be emptied periodically and the linings inspected. The porcelain brick type of mill lining tends to wear uniformly and when a worn place is found in a lining of this type, complete relining of the mill is generally called for. In the case of the Belgian stone, flint brick or Silex type of mill lining it is a common occurrence to find a small worn place which can be quite effectively patched. Any exposed iron in the mill will contaminate the enamel with small particles of iron resulting in black specks in the enamel. It is often difficult to keep iron from being exposed around the mill cover due to the tendency for the brick in the cover to chip off on the corners. This may be easily and effectively remedied by applying a piece of heavy rubber to the mill cover. Soft flint pebbles are known to have caused black specks by grinding into the enamel.

At the time the cover coat is delivered the stones should be carefully picked over and sorted and any foreign objects which may have found their way into the mill should be removed. Many tales are told of the objects which have been found in mills on various occasions. Upon one occasion the mill room men when removing the head of a mill, very faithfully covered the opening with a couple of burlap bags to keep out any dirt which might fall therein. During their absence the bags fell into the mill and upon their return they finished loading the mill with the bags in it. The result was that the enamel had whiskers. Recently some brass nuts were found in a frit basket. The electrician working nearby had inadvertently tossed them there.

Enamel should be sorted in clean containers and kept covered to keep out dirt. If wooden barrels are used for storage they should be inspected occasionally for splinters. When barrels become splintery they should be replaced or else burnt out with a large burner. Splinters or wood fibres in enamels burn out, leaving a carbonaceous skeleton forming a black speck.

Magnetic separators have come into wide use and are highly recommended by many individuals for removing iron particles and thus eliminating black specks. When the specks are caused by fairly large iron particles such as are introduced by defective mill linings, this is undoubtedly true. However, in the opinion of the author most of the extremely fine iron particles which are removed by a good separator are not harmful.

Black Specks from the Spraying Operation

The spraying operation is a potential source of black specks. The fan used for evacuating the spray dust from the spray booth creates a pronounced draft into the spray booth. Thus any dust or dirt that may be stirred up in the vicinity of the spray booth will tend to be carried into the booth with the attendant danger that it will come into contact with the ware being sprayed. The spray gun and the fluid and air hoses should be kept clean so that no dirt can fall from them to the ware. The spray booth should be kept clean inside and out, and it is a good policy to keep the inside wet.

A clean supply of compressed air for the spray guns is of paramount importance. Efficient separators to remove oil, water and scale are a necessity. Water and oil may even then condense between the separator and the spray gun. If the connection of the air hose to the spray gun is not tight and air is allowed to leak out, it is in effect a miniature refrigerating plant and will tend to condense oil and water from the air. Scale from the interior of the air pipe may be eliminated by attaching the air hose direct to the separator or by the use of brass pipe.

One case of black specks was traced to an air hose which was apparently in good condition. It was found that the inside lining of the hose was disintegrating and spraying out into the enamel in tiny specks. Occasional inspection of the lining of the air hose is desirable. A short piece should be cut off of one end and split open for examination. Synthetic rubber hose, which is quite resistant to the action of oil, is now available.

Black Specks from Shop Conditions

Clean shop conditions are reflected in higher quality ware. Clean boards, stands, floors, walls, ceilings and equipment make their contribution to freedom from black specks. It is desirable to use a vacuum cleaner on the ceiling, suspended pipes and other overhead objects which collect dirt. If freshly sprayed ware is loaded on boards and skids it is more likely to accumulate airborne dirt than if it is loaded directly upon a drier conveyor.

One plant is known to have had trouble with swarms of insects flying into the plant at night. These were attracted to the vicinity of the furnace, and when loads of ware were withdrawn

* Paper presented at a meeting of the Eastern Enamellers' Club in Baltimore, Md., U.S.A.

from the furnaces they dropped on to the ware causing spotting. Electric traps were employed to dispose of the insects. Aluminium paint on furnaces has been advanced as a potential and dangerous source of black specks.

Black Specks from Furnace Conditions

When a load of ware is run into a furnace, small pieces of scale may fly off from the edges of the ware and often on to the surface of the ware. If the firing is continued they are of course fused into the enamel. However, the ware can be withdrawn from the furnace and blown on prior to the fusing of the enamel and then returned to the furnace for completion of the firing.

A small amount of enamel glass may adhere to the firing points and upon charging into the furnace this may fly on the surface of the ware. Any piece of ware which falls off the points in the furnace should be removed immediately, for if it is left in the furnace it will produce scale which may be stirred up on running the fork in and out with subsequent contamination of the ware. Good practice would include periodical cleaning of the furnace by blowing out with air and periodical cleaning of the burning points by sandblasting. Continuous furnaces do not seem to give the same degree of trouble that box furnaces do. This is probably due to the slower heating up of the tools and to the hanging position of the ware.

Black Specks from the Ground Coat

Reboiling of the ground coat is responsible for a condition often referred to as black specking. While a considerable amount of work has been done upon the subject of reboiling, no satisfactory explanation of its occurrence has been offered, nor has any specific cure been advanced. Factors which effect reboiling are the enamelling iron, the pickling operation, composition and application of the ground coat, and firing conditions.

Copperheads if not covered by a second application of ground coat may cause black specking. Some copperheads may be covered directly with the white enamel without a second ground coat application. This can only be determined by trial. Fishscales may be responsible for specking in cover enamels. The usual remedy for this is to refire the ground coat, giving it about what would approximate a cover coat fire. In extreme cases a second ground coat may be called for. Isolated blisters and black specks, *i.e.*, those appearing only occasionally, such as perhaps three to ten in number on a sheet thirty-six by ninety-six inches, originate in the ground coat but their cause and prevention remains to be determined.

Recent American Developments in Enamelling Furnace Practice

RADIANT TUBE INNOVATION

Radiant tubes are apparently undergoing full-scale tests in American vitreous enamelling practice, and during the last two months two Papers have been read on the subject before technical societies. The earlier one was by Mr. S. M. Stoler, who lectured to members of the Eastern Enamellers' Club at Baltimore, and in the second case Mr. George M. Parker addressed a National Gas Conference at Chicago.

Mr. Stoler, in the course of his article, points out that internally fired tubes for high temperature work are a comparatively recent development in the ceramic field. Attempts were made some ten or twelve years ago to utilise refractory tubes, made up in silicon carbide and internally fired with gas or oil as a heating medium for vitreous enamelling furnaces, but they did not achieve a lasting place in the industry because of the fact that the tubes were not a monolithic or one piece structure, and soon opened up at the joints or failed through cracking of the refractory, thus permitting the products of combustion to enter the furnace chamber and spoil the work. The refractory type of tube was also heavy and bulky, it lacked mechanical flexibility and it was not easily repaired. Furnaces heated with these tubes soon gave trouble, and were usually converted to that old standby, the full muffle type.

The problem has been to find a tube material and a practical method of firing the tube. This problem has been solved, and its first application was made in the metallurgical field when the vertical tube type annealing cover was evolved. The first installations were made approximately four years ago, and now over 250 furnaces, and about 7,700 individual tubes, have been placed in operation, not only for bright annealing, but for vitreous enamelling, non-ferrous metal melting and kindred operations. The greater number of these installations have, of course, been in the heavy industries, but their use in vitreous enamelling is rapidly coming to the fore and present indications point to a growing use by enamellers of this new service tool.

The radiant tube has followed the development of the heat-resisting alloys, the manufacture of which has been standardised to such an extent that industry now depends upon and uses these alloys to a much greater degree than was possible five or six years ago. Increased knowledge of the properties and possibilities of these alloys, together with new and improved methods for controlling the flame characteristics of burners, coupled with extensive experimental work in securing accurate heat distribution on the external surfaces of tubes, have made the radiant tube possible.

Ni-Cr Alloy Used

The heat-resisting alloy used in the fabrication of these tubes is that commonly termed as 25:12, and contains 25 per cent. chromium, 12 per cent. nickel. This alloy is used in both the cast and wrought condition. The cast tubes are commonly formed in centrifugal casting machines, and have wall thicknesses approximately $\frac{1}{4}$ in. Fabricated tubes are made up from rolled alloy sheets of about No. 10 gauge material, and are welded gas-tight after forming to the desired size. It is, of course, highly desirable that the wall thickness of the tube be kept as thin as possible for efficient heat transfer, at the same time maintaining the necessary mechanical strength and freedom from burning out. It is interesting to note in this connection that a large manufacturer of radiant tubes reports that he is now using the fabricated tube, instead of the cast tube wherever possible, because of its greater freedom from pin-holes and generally improved operating life. This manufacturer states that he has not had a single tube fail at the weld.

The tubes are generally 3 in. dia. or larger, as it has been found difficult to secure good heat distribution with tubes smaller than 3 in. Tubes have been used in considerably larger diameters up to 6 in. dia., with the average ranging from $3\frac{1}{2}$ in. to 5 in.

The application of radiant tubes to vitreous enamelling furnaces is a comparatively simple problem in engineering. They lend themselves readily to installation along the hearth horizontally or to vertical mounting on the side walls. They can be placed close together or spread apart as desired to provide compensation for door and radiation losses. Expansion can be catered for by loops, bends, or sand seals. Of equal importance to enamellers is the fact that they are easily installed in existing furnaces of the fuel fired, full muffle or electrically-heated types.

Ignition or lighting of the tube burners has been simplified to a push-button operation through the use of high tension spark plugs. Automatic temperature control is applied in a similar manner to that now used on the full muffle type of fuel fired furnace, and the regulation is closer than in the full muffle type. Automatic temperature with gas fired radiant heaters—full floating control—is closer than standard "off" and "on" electric design. In enamelling furnaces using high-low control the temperature is closer than "on" and "off" electric furnaces.

The well-designed vitreous enamelling furnace requires a working chamber free from products of combustion. Radiant tube furnaces meet this requirement in several ways. One design utilises burners with sufficient flame velocity so that, if pin-holes or moderate openings occur in the tube wall, the atmosphere within the furnace chamber tends to be drawn or inspirated into the tube and carried along into the stack. Another design makes use of lower flame velocities and the products of combustion are pulled through the tubes by means of vacuum created at the exit ends.

Welded Repairs

If openings occur in the tube wall their repair is easily made by filling in the opening with alloy welding rod or by welding on a patch plate. Because of the inspirating action of the products of combustion within the tubes, the radiant tube furnace can usually be operated until such time as a lull in production permits the repair to be made. Complete figures are not yet available as to the fuel saving possible in vitreous enamelling furnaces by the use of radiant tubes, but it is apparent that some economies will be effected, when it is considered that the thermal conductivity of the alloy tube is vastly greater than that of silicon carbide muffles, and accordingly lower temperatures are required inside the tube than are required on the outside of the full muffles. Temperatures on the firing side of silicon carbide muffles have been measured at 1,093 to 1,150 deg. C. when operating on sheet steel, whereas inside tube temperatures will be a maximum of 982 to 1,010 deg. C. for identical operations. It is believed that the fuel savings in the radiant tube type of furnace should be at least 10 per cent. over the full muffle type.

Another enamelling furnace characteristic which is of vital importance to enamellers is that of reserve capacity. Many plants which installed electric furnaces in past years have found this characteristic missing at such times as they found it necessary to increase production. Electric furnaces are designed to fire a certain amount of ware and no more, which is a decided disadvantage in times of unusual production. There has been accordingly a tendency to make the capacity of these furnaces as much as 20 to 30 per cent. greater in order to handle these overloads, but the increased demand charge has kept this tendency at a minimum.

Existing installations of radiant tube enamelling furnaces have shown that they have the same characteristic reserve capacity as the full muffle type.

A Large Enamelling Furnace

Mr. Parker in his Paper deals with a large continuous enamelling furnace at the National Enamelling & Stamping Company's plant at Granite City, Ill., which is now heated with radiant gas-fired tubes. This was the first conversion of this kind to be made following the initial batch type experiments of the Committee on Industrial Gas Research. The furnace, as

(*Concluded on page* 186.)

Why use foreign enamels?

Most manufacturers of enamelled ware in this country put their faith in

Blythe ENAMELS

● When we put forward the claims of Blythe Enamels we do not seek to stress the fact that they are entirely British made—we rely instead on the QUALITY, RELIABILITY and SERVICE which we have to offer in our product.

We do want to point out, however, that when manufacturers buy foreign enamels, they send to foreign countries money which, if spent at home, would give more employment and greater prosperity.

Furthermore, the very countries who receive this money erect tariff walls which make it impossible for English enamels to be sold there.

Surely it pays in every way to use British Made enamels. Apart from the fact that you get better value backed by a guaranteed service, and a known source of origin, you actually increase the purchasing power within the country, which makes it possible for you to sell more of your own goods.

British Materials, Labour & Capital go to make Blythe ENAMELS British and Best.

BLYTHE COLOUR WORKS LIMITED.

CRESSWELL FOUNDED 1870 STOKE-ON-TRENT.

M 5

built, was a hairpin furnace having 120 ft. of travel in the drying space, 20 ft. in the preheater and 40 ft. in the hot zone, a total of 180 ft. of oven travel. Radiant gas tubes are located on both the walls and the bottom of the furnace. The tubes extend through 120 ft. of furnace travel. The products of the combustion continue to give off heat in the preheater and drying zones to an exit temperature of 200 deg. C. This means that 80 per cent. of the gross heat content of the gas burned is delivered to the furnace as useful heat. The temperatures maintained in the hot zone range from 840 to 900 deg. C., depending upon the kind of ware being burned.

Weld Leaks

Installation of the gas radiant tubes was completed and the furnace was lighted on June 15, 1936. The gas tubes at the present time appear to be in good shape and should continue to give service without major maintenance for several more years. After the first few months of operation small leaks appeared in some of the welds, probably due to unrelieved strains set up at the time the welds were made, but no further leaks have developed and it is believed that the condition is stabilised. The amount of leakage into the furnace is negligible, and has not affected the quality of the ware. It is believed that welding troubles could be solved if the welds were made and annealed on the job, using small gas-fired annealing covers especially built to set the tubes in place. It is also possible that it might be desirable to use Vanstone joints on all joints made up on the job. Since the proper operation of these tubes requires that they be under negative pressure, leakage of gas into the furnace seems unlikely, if the cross section of the tubes is sufficient and negative pressure is actually maintained within them.

Increased Production

Production through this furnace has been increased 20 per cent. over the former arrangement. The ware is better dried and there is a smaller temperature differential between the top and bottom of the furnace. This probably results from the fact that radiant gas tubes are installed in the bottom. The thermal capacity of the radiant tubes on account of their mass seems to provide an added advantage. In changing from light to heavy ware the gas tubes recover rapidly. The radiant tubes, as installed, are controllable within close limits, and they react quickly to changing heat input. The increase in production is attributed to the higher heat input into the furnace now possible.

The matter of tube support is of great importance, and it is believed that in so far as this installation represents present knowledge the ultimate design has by no means been reached. There is no reason why alloy tubes of this kind should not last for very long periods of time, providing stresses and strains are relieved in the bends and joints. Undoubtedly the experience gained in this large furnace will be useful in future design.

Tensile Tests on Tin Bearing Alloys White Hot

The latest contribution by the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C.2, to the study of tin base bearing metals is contained in Technical Publication Series A Number 58 by H. Greenwood, M.Sc. Because the temperature of bearings when working may be much above that of the air it was decided to examine the tensile behaviour of typical tin base bearing alloys at temperatures up to 175 deg. C. and to try the effects of additions of lead and cadmium. It was found that as the temperature rises the maximum stress and yield point fall fairly uniformly, while elongation and reduction in area increase. Cadmium markedly improves tensile strength of the alloys when cold, but is of little benefit when they are hot, and the effect of 4 per cent. of lead, although slightly beneficial when cold, is reversed at the higher temperatures. Copies of the above publication may be obtained free of charge from the Council.

Institute of Vitreous Enamellers' Annual Conference in Birmingham

The fourth annual conference of The Institute of Vitreous Enamellers will be held at the Grand Hotel, Birmingham, from October 8 to 10. The newly elected President, Brigadier-General Sir Harold Hartley, will preside. Below is a brief outline of the programme which has been arranged.

FRIDAY, OCTOBER 8.

4 p.m.—Annual general meeting. Induction of Brigadier-General Sir Harold Hartley, Kt., C.B.E., F.R.S., M.C., M.A., as President of the Institute. Election of officers.

7 p.m.—Reception at the Grand Hotel.

7.30 p.m.—Annual banquet. The principal guests will be the Right Hon. the Earl of Dudley, M.C., M.P., and the Lord Mayor of Birmingham.

10 p.m. to 2 a.m.—Dance and cabaret.

SATURDAY, OCTOBER 9.

9 a.m.—Leave Grand Hotel by coach for a visit to the works of the General Electric Company, Limited, Witton.

11 a.m.—Leave the General Electric Company's Witton works by coach for the company's works at Landor Street.

1 p.m.—Return to the Grand Hotel, for luncheon at 1.30 p.m.

3 p.m.—Meeting at the Grand Hotel. Brigadier-General Sir Harold Hartley will deliver his Presidential Address. Two Papers, entitled "The Evolution of Enamelling," by W. E. Benton, chief chemist, Cannon Iron Foundries, Limited, and "Stannic Oxide as Opacifiers in Wet Enamels," by Dr. Ludwig Stuckert, of Germany, will be presented for discussion.

5 p.m.—Tea.

In the evening, arrangements have been made for a party to visit the Prince of Wales' Theatre. Afterwards supper will be served at the Grand Hotel at 11 p.m.

SUNDAY, OCTOBER 10.

A works visit to The Triplex Foundry Company, Limited, Dudley Port, Tipton, Staffs, has been arranged to take place in the morning.

Wounds Caused by Light Metals

In a Paper on "Wounds Caused by Light Metals," read before the eighth technical congress of L'Association des Industriels de France, M. GISSEL states that the light metals, such as Duralumin and Elektron, are specially liable to cause injury to employees who have to handle them. In one German factory two thousand minor injuries were caused by such metals. A close study of these cases enabled the following symptoms to be pronounced typical. After a period which varied from one to three days, abcesses and phlegmons appeared and many of the injured also showed traces of lympangitis. In more serious cases there were indications of general poisoning. It was noted that instead of local running sores there were scattered swellings of the outer skin and also of the fatty subcutaneous tissues which are less easy of access. Some employees complained, after several months' service, of a general tendency to furunculosis and eczema.

A microscopic examination of Duralumin showed that it possessed a characteristic not shared by other metals such as iron, copper, etc. It was formed of sharp-edged particles of such a kind that the wounds produced showed a special degree of laceration and were especially liable to mortify. Also, the splinters of this metal showed an extraordinary facility for absorbing all varieties of bacteria.

The treatment of wounds made by these metals should, the article suggests, be as follows:—

(*a*) Wash the neighbourhood of the wound with benzine.

(*b*) Examine the wound with the aid of forceps and a magnifying glass in order to ensure that no particles of metal remain in it.

(*c*) Wash the wound with hydrogen peroxide, mixed with rivanol in a proportion of 1/1,000.

(*d*) Apply a dressing.

For subsequent treatment use should be made of an ointment made up as follows:—

Liquor alumin. acetate	5
Peru Balsam	10
Lanolin	10
Pasta Zinci et Salycil. ad	100

If the above precautions are taken the wounds caused by light metals will, generally speaking, give little trouble. Everything depends, of course, on the injured employee reporting for treatment without delay.

Carnegie Research Fund

The Council of the Iron and Steel Institute are prepared to make annually a limited number of grants from the Research Fund founded by the late Mr. Andrew Carnegie in aid of metallurgical-research work. The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under 35 years of age, must apply before September 30, on a special form to be obtained from the Secretary of the Institute.

The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100. The grant will be divided into four instalments. Of these, the first will be paid on or about January 1, and the second and third on or about July 1 and October 1, subject to the receipt of adequate progress reports. The final instalment will not be paid until a complete report on the entire research, in a form suitable for publication, has been received; this should be submitted not later than the following May 31 (in exceptional cases, an extension of an additional year may be granted).

The Council may, at their discretion, award a further grant in aid of any particular research work, which seems to them sufficiently meritorious to justify further assistance. The results of the research shall be communicated to the Iron and Steel Institute, which will have the right of priority of publication in full, and will bear the whole costs thereof; subject to the approval of the Council, they will be printed in the "Carnegie Scholarship Memoirs," a volume of which is published in December of each year.

Further particulars may be obtained from the Secretary, Iron and Steel Institute, 28, Victoria Street, London, S.W. 1.

Catalogue Received

Foundry Products on Hire Purchase. Of importance to a number of foundries which manufacture coal-burning apparatus is a scheme which has been sponsored by the Coal-Burning Appliances Joint Consultative Board for providing financial facilities to enable builders' merchants and ironmongers to offer their customers extended credit terms for the purchase of heating and cooking appliances. The details of the scheme are printed in a booklet obtainable by writing to the secretary of the Board, Mr. A. McClure, 54, Victoria Street, London, S.W.1. Most of the responsible employers' federations are represented on the Board.

Clean Iron

Machine cast iron is *clean*—all iron—free from sand fused on the surface. The absence of the usual siliceous skin exposes the whole surface at once to the melting process, gives quicker melting and requires less coke in the cupola. A fuel saving of quite 20% is common, besides an economy in limestone for fluxing, up to 50%

Machine cast pig iron is uniform throughout the whole cast, easy to handle by hand or magnet; there are no unwieldy sows and the iron can be broken readily as it is notched for this purpose.

THE UNITED STEEL COMPANIES LTD

Write for the leaflet "Machine Cast Pig Iron" to the Publicity Dept., The United Steel Companies Ltd., 17, Westbourne Road, Sheffield, 10.

WORKINGTON

MACHINE CAST PIG IRONS

WORKINGTON IRON & STEEL COMPANY · WORKINGTON · CUMBERLAND

BRANCH OF THE UNITED STEEL COMPANIES LIMITED

W.31

This Week's News in Brief

Trade Talk

WILLIAM BEARDMORE & COMPANY, LIMITED, Glasgow, have received an order from the South Indian Railway Administration for 50 pairs of metre gauge carriage and wagon wheels.

NEGOTIATIONS ARE PROCEEDING for the reopening of Langloan Iron Works, Coatbridge, which has been closed for over six years. Thomas W. Ward, Limited, Sheffield, bought the works two years ago.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, have received an order from the Bhavnagar State Railway Administration of India for the supply of 54 cast-steel locomotive hornblocks and wedges.

FERRO-MANGANESE is to be produced at the Newcastle Ironworks, Natal, of the Union Steel Corporation of South Africa, using Postmasburg ore. It is hoped to make South Africa independent of foreign ferro-manganese in a short time.

THE "POLSKAROB" POLSKO-SKANDYNAWSKIE TOWARZYSTWO TRANSPORTOWE S.A., of Gdynia, Poland, have placed a contract with Burntisland Shipbuilding Company, Limited, to build a modern self-trimming collier of 4,300 tons capacity.

THE L.M.S. RAILWAY have placed orders for ten bogie trolley wagons—four of 40 tons with G. R. Turner, Limited, Langley Mill (Notts), and three of 50 tons and three of 20 tons with the Fairfield Shipbuilding & Engineering Company, Limited, Chepstow.

WILD-BARFIELD ELECTRIC FURNACES, LIMITED, of Elecfurn Works, North Road, Holloway, London, N.7, have prepared a series of lantern slides illustrating electric-furnace developments. These will be loaned to any technical school or scientific institute on application.

SOUTH WALES is to resume imports of Spanish iron ore immediately. Guest Keen Baldwins Iron & Steel Company, Limited, announced last week that they had chartered a number of ships to restart the trade which was interrupted when General Franco captured Bilbao.

MR. FRED FIRTH, chairman of Brightside Foundry & Engineering Company, Limited, in his address to the shareholders, stated that the board had sanctioned the installation of a continuous casting plant at the works of their subsidiary company, Moorwoods, Limited, of Harleston Works, Sheffield.

A SLIGHTLY UNFAVOURABLE repercussion of the Shanghai trouble—fortunately more than offset by a general increase in their export trade—has been experienced by J. Gray & Sons, Limited, of 5, Victoria Street, London, S.W.1, by a cessation of orders for enamel frit from a complete enamelling plant they recently installed in that city.

THE BATTELLE MEMORIAL INSTITUTE at Columbus, Ohio, U.S.A., has extended its research facilities by building a new four-storey building which houses a complete foundry. This is equipped for the production of ingots and castings in steel, special alloys, cast or malleable iron or non-ferrous metals. The melting equipment includes direct and indirect arc furnaces, a high-and-low-frequency induction furnace, a cupola and several crucible furnaces.

VICKERS, LIMITED, are to redeem on December 1, 1937, at 103 per cent., the whole of their £2,000,000 (nominal) 5½ per cent. first mortgage debenture stock. Stockholders will be paid on October 1, 1937, the full half-year's interest, *viz.*, £2 15s., less tax, per £100 stock, due on that date, and interest, less tax, from October 1 to November 30, 1937, both days inclusive, will be paid with the redemption money. The stock will cease to carry interest after the last-mentioned date. No transfer of the 5½ per cent. first mortgage debenture stock of the company will be registered after October 30, 1937.

Removing Scratches from Enamelled-Wares.—According to the "American Enameller," Mr. R. Carns, of the O'Keefe & Merrett Company, Los Angeles, removes scratches arising from process accidents on enamelled components by using the ordinary spray gun fed with milled cover coat as the abrasive as a "sand blast." This effectively removes all marks when held at a suitable distance, but it may affect the gloss. This, however, is restored by refiring.

Personal

MR. JAMES WRIGHT retired last week after 43 years' service with Pott, Cassells & Williamson, iron and brass founders, of Motherwell.

DR. BERNARD OSANN, the father of German foundry metallurgical practice, reached the age of 75 last Friday. On behalf of his British colleagues, and personally, we extend very hearty congratulations and good wishes for his health and future happiness.

Wills

VENTOM, T. E., of London, brass and iron founder	£10,878
MILLER, W. M., of Edinburgh, civil and mining engineer	£121,290
SWAN, W., of Arbroath, director of Douglas Fraser & Sons, Limited, iron-founders and engineers	£12,761

Obituary

ENGINEER-COMMANDER WILLIAM HENRY WOOD, a former director and engineering manager of John Brown & Company, Limited, Clydebank, has died, aged 70.

MR. THOMAS KINGSFORD WILSON has died at Sheffield at the age of 75. He was a director of Joseph Rodgers & Sons, Limited, cutlery manufacturers, and other companies.

MR. JAMES CLARK, who for fifty-four years was employed by Smith & Wellstood, Limited, Columbian Foundry, Bonnybridge, died at his home on August 24. He was in his 89th year.

MR. ROBERT SHOTTON CORKING, for over 30 years a director of Cortin & Corking, Limited, chemical plant manufacturers and non-ferrous metal founders, of St. Lawrence Road, Newcastle-upon-Tyne, has died, aged 60.

Company Reports

W. Canning & Company, Limited.—Interim dividend of 5 per cent. in respect of the six months trading to June 30.

F. H. Lloyd & Company, Limited.—Dividend of 2½ per cent. on the 5 per cent. cumulative preference shares for the half-year ended June 30 last, and final dividend of 5 per cent. on the ordinary shares, making 8 per cent. for the year.

Braithwaite & Company, Engineers, Limited.—Trading profit for the year ended March 31, £44,084; net profit, after charging £7,325 for depreciation, £27,074; brought in, £6,049; to employees' pension fund, £500; one year's dividend on the preference shares, bringing payments down to March 31, 1934; carried forward, £24,186.

Brightside Foundry & Engineering Company, Limited.—Profit for year to June 30, after depreciation and income-tax, £68,461; brought in, £18,497; preference dividend, £2,500; dividend of 15 per cent., and a special bonus of 7½ per cent. on the ordinary shares, £22,500; to staff pension fund, £1,000; to general reserve, £40,000; carried forward, £20,957.

Blakey's Boot Protectors, Limited.—Net profit for the year ended June 30, £34,233; provision for taxation, £10,400; brought in, £13,823; final dividend of 7½ per cent. on the ordinary shares, making 15 per cent. for the year; carried forward, £5,742. It is proposed to capitalise £20,081, which is to be distributed to ordinary shareholders in the form of ordinary 5s. shares in the proportion of one new share for every five shares held.

Correction.—In the section of Mr. H. H. Shepherd's Paper, "Malleable Iron Melting Practice," published in our last week's issue, line 41, column 2, page 164, should read: "claimed that a 12- to 15-ton unit will melt a charge."

Output of Pig-Iron, Steel and Finished Products

The British Iron and Steel Federation in its Statistical Bulletin for July, 1937, reports that production of pig-iron and ferro-alloys in the United Kingdom in July amounted to 729,300 tons compared with 699,300 tons in June, and 665,600 tons in July, 1936. The July figure is the highest since September, 1920, when 741,000 tons were produced. The total production for the first seven months of the year is 4,740,300 tons, and exceeds that of the corresponding period of 1936 by 7.4 per cent. The production of steel ingots and castings in July amounted to 1,059,200 tons compared with 1,106,400 tons in June, and 974,100 tons in July, 1936. The total production for the first seven months of the year is 7,397,600 tons and exceeds that of the corresponding period of 1936 by 10.1 per cent. According to returns received from firms employing 124,355 workpeople, the average earnings per head in June amounted to £3 13s. 11d., compared with £3 10s. 2d. in May and £3 11s. 6d. in April.

Linthorpe Ironworks Acquired by Dorman, Long & Company

Dorman, Long & Company, Limited, Middlesbrough, have acquired the extensive Linthorpe Ironworks from the Linthorpe Dinsdale Smelting Company, Limited. There are six blast furnaces with a wharf and an extensive river frontage on the site which adjoins Dorman, Long & Company's Acklam Iron and Steelworks, Middlesbrough.

The whole of the works has been idle since June, 1930, but prior to that date the blast furnaces were engaged principally on the production of hematite. It is understood that the furnaces and other plant are to be demolished for scrap, which is urgently needed at the present juncture, and thereafter the site will be available for extensions to the Acklam plant, which is one of the most efficient in the district. The vendors still retain possession of the Dinsdale Ironworks, but these also have been idle for a number of years.

The capital of the Linthorpe Dinsdale Company is represented by 520,000 fully paid £1 shares which are privately held. The directors are Mr. Penry Williams, Mr. George Hedley and Mr. H. C. Torbock.

Contracts Open

Cairo, September 22.—Pumping machinery, etc., for the Egyptian Ministry of Public Works, Main Drainage Department. The Department of Overseas Trade. (Reference T.Y. 18,479/37.)

Stockport, September 23.—30,000-kw. turbo-alternator, with condenser and auxiliary plant, of British manufacture, for the Town Council. Mr. G. H. Oldroyd, borough electrical engineer, Electricity Offices and Showroom, 23, Tiviot Dale, Stockport. (Fee £3 3s., returnable.)

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Grundys (Metal Foundry), Limited.—Capital, £1,000. Directors: R. J. Grundy, Dicky Cragg, Sparkbridge, Ulverston; P. K. Lee.

Forthcoming Event

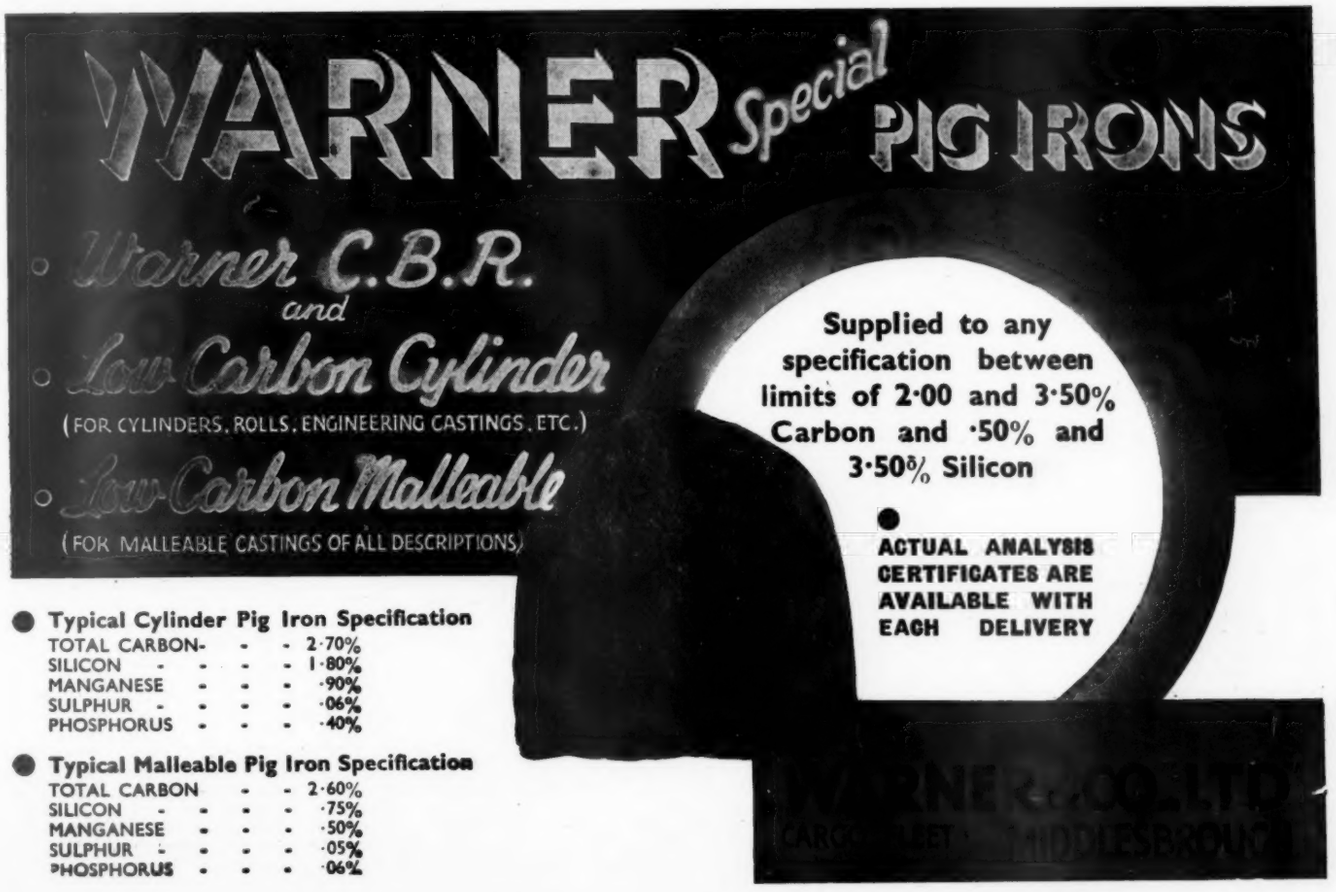
SEPTEMBER 16 TO OCTOBER 2.

Engineering and Marine Exhibition:—Incorporating the Foundry Trades' Exhibition and the Welding Exhibition, at Olympia, London, W.14.

HIGH GRADE MALLEABLE — IRON CASTINGS —

PROMPT DELIVERIES

BIRMINGHAM STEEL CO., LTD.,
202, FAZELEY STREET, BIRMINGHAM, 5
Telephone: VIC. 1941 (6 lines)


WARNER Special PIG IRONS
Warner C.B.R.
and
Low Carbon Cylinder
(FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
Low Carbon Malleable
(FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)
Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon
ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY
Typical Cylinder Pig Iron Specification
TOTAL CARBON - - - 2·70%
SILICON - - - - 1·80%
MANGANESE - - - ·90%
SULPHUR - - - - ·06%
PHOSPHORUS - - - ·40%
Typical Malleable Pig Iron Specification
TOTAL CARBON - - 2·60%
SILICON - - - - ·75%
MANGANESE - - - ·50%
SULPHUR - - - - ·05%
PHOSPHORUS - - - ·06%

Raw Material Markets

Stoppages at the consuming plants, owing to holidays, continue to ease the situation in the iron and steel trade. Demand is less insistent and deliveries generally are proving more adequate for current requirements. Unfortunately, this state of affairs is unlikely to obtain for very long, and as soon as the works return to normal operations, the stringency of supply is again expected to be felt.

Pig-Iron

MIDDLESBROUGH.—An increase of output is urgently needed in this area and it is hoped that the plans now believed to be under consideration for an expansion of production will materialise at an early date. Pease & Partners, Limited, have recently started an additional blast furnace at their Normanby works for the production of hematite. New business in foundry iron, of course, is quite out of the question and delivery arrears are heavy. Exports of hematite have been slightly higher during the holiday period, but as soon as the works resume full-capacity working in the near future, a decline is certain to take place in the tonnage despatched overseas. Mixed numbers of hematite are quoted at 122s. 6d. per ton on the North-East Coast, less 5s. rebate, 123s. in Scotland, 128s. in Sheffield and 133s. 6d. in the Midlands.

LANCASHIRE.—The holidays appear to have had little appreciable effect in this area and the demand has been fully maintained. Machine-tool makers, heavy electrical engineers and light-castings makers are all calling for full deliveries, as also are the general engineers and the jobbing foundries. Machine-tool makers, in many cases, are stipulating deliveries about 15 months ahead for new business, while there have been instances of as much as two years.

MIDLANDS.—Consumers generally are well placed for deliveries, although the supply is barely sufficient to meet the demand, and there is the prospect, too, of a considerable expansion in requirements in the near future. The call for medium- and low-phosporus iron is heavy and it is not easy to procure supplies. Scottish grades are quoted from about £6 10s. to £7 5s. Refined iron is quoted at a minimum of £8 2s. 6d. per ton. Purchases of Continental pig-iron appear to have ceased.

SCOTLAND.—Fifteen blast furnaces continue to be operating in this area, but a greatly increased production could well be taken up. No. 1 foundry is quoted at 115s. 6d. and No. 3 113s. per ton, f.o.t. furnaces. No. 3 Cleveland iron is still quoted at 104s., f.o.t. Falkirk, and 107s., f.o.t. Glasgow, but these figures are purely nominal. It would appear that still heavier imports of Continental iron will be made, as prices are now more on a level with home quotations. The steelworks continue to take up good tonnages of hematite and basic. Steel-making irons are as follow:—Mixed numbers hematite, 123s.; Scottish basic, 107s. 6d.; English and Indian basic, 100s., all less 5s. rebate, delivered steelworks here.

Coke

Supplies of foundry coke are adequate at the moment, but the outlook for the winter is not too satisfactory, and there is every prospect of a shortage. For delivery to Birmingham and district, best Durham coke is quoted at 51s. 6d., with a few shillings extra for special qualities, and Welsh coke at from 52s. 6d. to 69s. per ton.

Steel

There are signs of increased activity in the steel trade as the close of the holiday season approaches, and greater pressure is being exercised by the consuming industries to obtain supplies, states the official report of the London Iron and Steel Exchange. The situation remains difficult, as the producing firms have sold their output for the remainder of this year. The scarcity of semi-finished steel is still acute, and, although increased quantities of Continental semis are reaching some districts, they are not sufficient entirely to relieve the shortage. More regular deliveries of British steel are arriving at the consuming works, and the position seems to be improving. The demand for finished steel is still in excess of the supply in spite of the record production, and consumers are endeavouring to place orders for execution next year. The tendency, however, is for the manufacturers to adopt a conservative policy with regard to such far forward business, owing to the congested state of their books.

Scrap

Although imports of scrap are on a considerably increased scale, supplies continue to be taken up as fast as they become available and there is a ready market at keen prices. The cost of imported material is much in excess of home-produced scrap. Although the campaign for raising supplies of scrap has generally had good results, it is reported from Lancashire that the position has not been materially improved as a result of the search. Conferences have been held in the district recently between representatives of the North-Western Scrap Metals Association and those responsible for the scrap collection scheme with a view to increasing supplies.

Metals

Consuming interest in non-ferrous metals at the present time is quiet owing to holiday influences. The trend of developments in the Far East is being closely watched. Should the conflict be intensified prices are likely to rise on the metal market.

Copper.—Although this market is dull at the present time, it is anticipated that there will be a revival of activity in the early autumn. New business is quiet, but heavy deliveries against contracts have recently been made. In the United States, sales are brisk, although not so heavy as they were at the beginning of August. It is not likely that the demand will be maintained much longer, as consumers are believed to be well covered.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £55 6s. 3d. to £55 8s. 9d.; Friday, £55 6s. 3d. to £55 8s. 9d.; Monday, £54 16s. 3d. to £54 18s. 9d.; Tuesday, £55 1s. 3d. to £55 3s. 9d.; Wednesday, £55 6s. 3d. to £55 7s. 6d.

Three Months.—Thursday, £55 12s. 6d. to £55 13s. 9d.; Friday, £55 11s. 3d. to £55 12s. 6d.; Monday, £55 2s. 6d. to £55 3s. 9d.; Tuesday, £55 7s. 6d. to £55 8s. 9d.; Wednesday, £55 11s. 3d. to £55 12s. 6d.

Tin.—There is little change to report in the condition of this market. New buying is small in this country, but consumers in the United States, especially the tinplate industry, have shown more interest in the metal, and consumption is at a high rate. The August issue of the International Tin Research and Development Council's Bulletin, published by The Hague Statistical Office, reveals that the world's production of tin in the first half of 1937 was 92,303 tons, and world consumption was 94,863 tons. Production has increased by 9,415 tons, as compared with the first half of 1936, and consumption by 14,944 tons. In the 12 months ended June, 1937, world production totalled 187,779 tons, while apparent consumption showed an increase of 12.7 per cent. over the consumption for the previous 12 months, at 177,384 tons. Among countries in which tin consumption shows a definite upward trend are Holland, Czechoslovakia, Poland, Yugo Slavia and South Africa. World production of tinplate in the year ended June, 1937, increased by 22 per cent., as compared with the preceding year, from 3,313,000 tons to 4,038,000 tons. The consumption of tin in the United Kingdom in July, 1937, is given as 2,723 tons, compared with 2,841 tons in the previous month and with 1,701 tons in July, 1936.

Official quotations were as follow :—

Cash.—Thursday, £260 15s. to £261 5s.; Friday, £259 15s. to £260; Monday, £260 to £260 5s.; Tuesday, £261 5s. to £261 15s.; Wednesday, £261 15s. to £262.

Three Months. — Thursday, £259 15s. to £259 17s. 6d.; Friday, £258 15s. to £259; Monday, £259 to £259 5s.; Tuesday, £260 to £260 5s.; Wednesday, £261 to £261 5s.

Spelter.—A dull tone has prevailed in this market, and the immediate future is likely to display little change. Unfulfilled orders at American smelters continue to accumulate. It is understood that a fair tonnage has continued to pass into the United States from Canada. High-grade zinc is usually involved, and the shortage of this quality throughout the world is still acute.

Daily market prices :—

Ordinary.—Thursday, £23 1s. 3d.; Friday, £23 1s. 3d.; Monday, £23 1s. 3d.; Tuesday, £23; Wednesday, £22 16s. 3d.

Lead.—Consumption continues to be well maintained, although the tone of the market is dull at the present time. In the United States, also, quieter conditions obtain, as users are well covered for supplies.

The general outlook for the building industry, according to the current issue of the "Building Industries Survey," published by the Building Industries National Council, continues to be very favourable. Activity in the industry, it is stated, is at a very high level. The contracting sections of the industry are stated to be very busy, especially in connection with non-residential buildings. Factory construction is at a high level, and continues to increase. Housing activity is also stated to be at a high level. The position of public works contracting continues to improve. The materials industries are very active, and are making heavy deliveries. This favourable position, the survey states, seems assured for some time to come by the programme of construction in connection with slum replacement and overcrowding abatement, by plans for factory construction and extension, and by the rearmament programme. This survey of the building industries is of particular interest to the lead market, as large tonnages of lead are consumed by those industries. The problem of the shortage of supply of structural steel remains, but the Special Committee for Public Relations of the Building Industries National Council have recently stated that there has been a considerable change-over to alternative methods of construction.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £21 16s. 3d.; Friday, £21 16s. 3d.; Monday, £21 12s. 6d.; Tuesday, £21 11s. 3d.; Wednesday, £21 15s.

Scrap.—Consumers continue to show little interest in the market, and business has again been slow to materialise. An early resumption of buying is anticipated. Prices are inclined to fall a little.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £43; foil, £94 to £98. Copper, £52 to £56; braziery, £49. Brass (clean), £32 to £35. Zinc, £15. Lead, £20 10s. Gunmetal, £51 to £53.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

468,177. BYRNE, E. L. W. (American Smelting & Refining Company). Casting metal.

468,193. GROGAN, F. S. Electric furnaces and ovens.

468,309. INDUSTRIE LORRAINE. Reinforced cast-iron pipe for water or other fluids under pressure.

468,366. DEUTSCHE HOUGHTON FABRIK GES. Fusion baths for the cementation of iron and steel.

468,626. LINDE AIR PRODUCTS COMPANY. Methods of and apparatus for hardening the inner wall surface of hollow metallic bodies.

468,696. WINGET, LIMITED, and LANGFORD, H., and MALIN, L. D. [Legal representative of MALIN, W. G. (deceased)]. Means for clamping in position the loose walls of mould boxes.

468,702. HARBORD, F. W., and HARBORD, V. Apparatus for casting metal.

468,757. FOLLSAIN SYNDICATE, LIMITED, and SAINDERICHIN, N. Processes for case-hardening steel.

Iron Ore in Cumberland

Kennedy Bros., Limited, ore merchants, of Ulverston, are to prospect for ore near Frizington Parks, Cumberland. Mr. T. S. Durham, engineer to the Lowther Estates, Limited, and who has been connected with Whitehaven Collieries, Limited, is consulting engineer for Kennedy Bros., Limited. Other developments which are taking place in the district include a new shaft which is being opened at Bigrigg by the Barrow Hematite Steel Company, Limited, who are also sinking a shaft at Cleator Moor.

WE CORDIALLY INVITE YOU TO

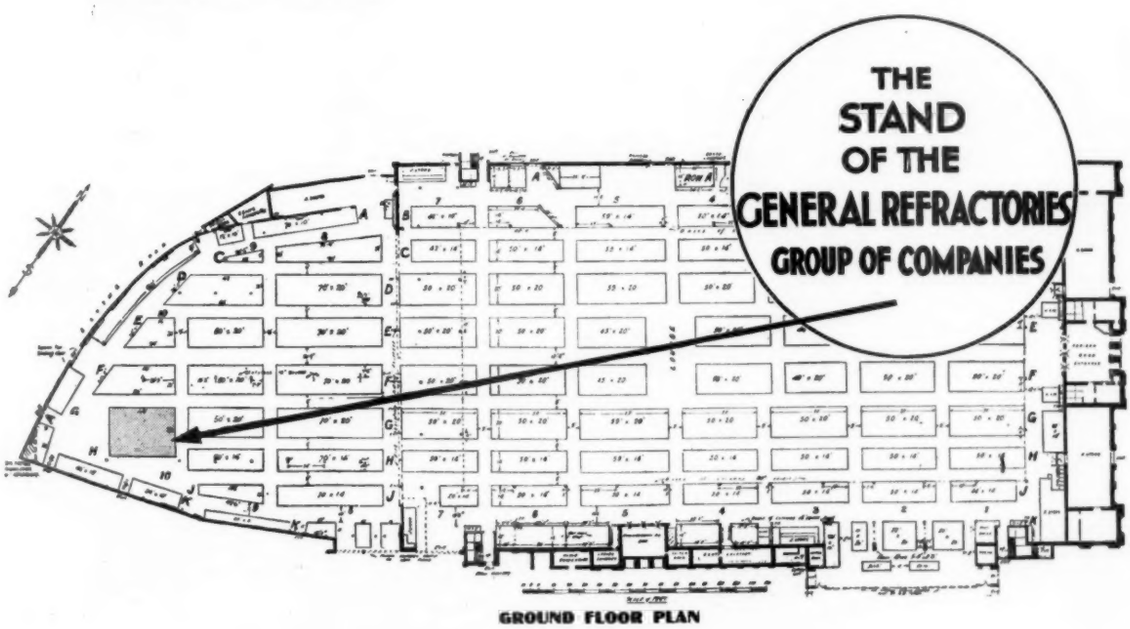
VISIT OUR STAND

AT THE

FOUNDRY TRADES EXHIBITION

No. 21. ROW G.

GROUND FLOOR



GROUND FLOOR PLAN

THERE WILL BE SPECIAL DISPLAYS OF:

Moulding Sands, Basic Refractories, Insulating Materials, Firebricks, Silica Bricks, Cements and Plastic Refractories.

GENERAL REFRACTORIES LIMITED

Head Office:

GENEFAX HOUSE, SHEFFIELD

Telephone: 31113 (6 lines) Telegrams: "Genefax, Sheffield"

London Office:

RUSSELL HOUSE, ADLEPHI, W.C.2

Telephone: Temple Bar 3511 Telegrams: "Genefax, Rand, London"

Manufacturers of heat resisting and heat insulating materials of every description

RAW MATERIALS—PRICE LIST

(Wednesday, September 1, 1937)

COPPER

	£	s.	d.
Standard cash	55	6	3
Three months	55	11	3
Electrolytic	61	5	0
Tough	60	10	0
Best selected	61	0	0
Sheets	91	0	0
India	73	0	0
Wire bars	62	5	0
Ingot bars	62	5	0
H.C. wire rods	67	0	0
Off. av. cash, August	57	3	10 1/4
Do., 3 mths., August	57	7	1 1/2
Do., Sttlmnt., August	57	3	9 1/2
Do., Electro, August	64	1	8
Do., B.S., August	63	16	4 3/4
Do., wire bars, August	64	11	5 1/2
Solid drawn tubes			14 1/2d.
Brazed tubes			14 1/2d.
Wire			10d.

BRASS

Solid drawn tubes	12 1/2d.
Brazed tubes	14 1/2d.
Rods, drawn	11 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 1/2d.
Wire	9 5/8d.
Rolled metal	9 1/2d.
Yellow metal rods	7 1/2d.

TIN

	£	s.	d.
Standard cash	261	15	0
Three months	261	0	0
English	262	0	0
Bars	263	10	0
Straits	264	15	0
Eastern	261	10	0
Banca (nom.)			—
Off. av. cash, August	264	15	1 3/4
Do., 3 mths., August	263	0	10 5/8
Do., Sttlmt., August	264	15	5 1/4

SPELTER

	£	s.	d.
Ordinary	22	16	3
Remelted	19	10	0
Hard	18	10	0
Electro, 99.9	25	8	9
English	24	0	0
India	19	10	0
Zinc dust	29	0	0
Zinc ashes	7	10	0
Off. aver., August	24	4	3 17/32
Aver. spot, August	24	2	9 1/2

LEAD

	£	s.	d.
Soft foreign, ppt.	21	15	0
Empire (nom.)	22	7	6
English	23	15	0
Off. aver., August	22	12	9 1/32
Aver. spot, August	22	12	1 5/64

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	36	10	0	to 37	0	0
Do., V.M. ex-whse.	36	10	0	to 37	0	0
Rods				31	0	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	92	10	0	to 93	10	0
Chinese, ex-whse. (nom.)				78	0	0
Crude, c.i.f.				69	0	0

QUICKSILVER

	£	s.	d.
Quicksilver	13	12	3

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.
Ferro-silicon—			
25%	14	10	0
45/50%	12	0	0
75%	17	0	0
Ferro-vanadium—			
35/50%	12/8 lb. Va		
Ferro-molybdenum—			
70/75% carbon-free	4/9 lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	9d. lb.		
Ferro-phosphorus, 20/25%	£22		
Ferro-tungsten—			
80/85%	7/6 lb.		
Tungsten metal powder—			
98/99%	7/7½ lb.		
Ferro-chrome—			
2/4% car.	35	0	0
4/6% car.	24	10	0
6/8% car.	24	0	0
8/10% car.	24	0	0
Ferro-chrome—			
Max. 2% car.	36	0	0
Max. 1% car.	38	5	0
Max. 0.5% car.	41	0	0
70% carbon-free	10d. lb.		
Nickel—99.5/100%	£180 to £185		
"F" nickel shot	£165	0	0
Ferro-cobalt, 98/99%	8/6 to 8/7 lb.		
Metallic chromium—			
96/98%	2/5 lb.		
Ferro-manganese—			
76/80% loose £18 15	0 to 19	5	0
76/80% packed £19 15	0 to 20	5	0
76/80% export	£24	0	0
Metallic manganese—			
94/96% carbon-free	1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 7d.
Finished bars, 18% tungsten	3s. 6d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¼ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales (West)—	£	s.	d.	£	s.	d.
Heavy steel, best	3	7	6	to 3	10	0
Mixed iron and steel	3	5	0	to 3	7	6
Heavy cast iron	3	8	0	to 3	10	0
Good machinery	4	0	0	to 4	5	0
Cleveland—						
Heavy steel, best	3	6	6	to 3	9	0
Steel turnings				2	15	0
Heavy cast iron				4	7	6
Heavy machinery				4	10	0
Midlands—						
Short heavy steel	3	17	6	to 4	0	0
Light cast-iron scrap				3	2	6
Heavy wrought iron	4	0	0	to 4	5	0
Steel turnings				2	5	0
Scotland—						
Heavy steel, best	3	4	6	to 3	7	0
Ordinary cast iron	4	5	0	to 4	7	6
Cast-iron borings	2	0	0	to 2	2	6
Wrot-iron piling	4	17	6	to 5	0	0
Heavy machinery	4	12	6	to 4	15	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	45	0	0
Brass	29	10	0
Lead (less usual draft)	18	10	0
Tea lead	12	10	0
Zinc	15	0	0
New aluminium cuttings	72	0	0
Brazier copper	41	0	0
Gunmetal	44	0	0
Hollow pewter	170	0	0
Shaped black pewter	126	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	103/6
,, No. 3	101/-
,, No. 4	100/-
Forge No. 4	100/-
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	103/-
,, No. 3 fdry.	106/-
Northants forge	100/6
,, fdry. No. 3	103/6
,, fdry. No. 1	106/6
Derbyshire forge	103/-
,, fdry. No. 3	106/-
,, fdry. No. 1	109/-
Scotland—	
Foundry, No. 1, f.o.t.	115/6
,, No. 3, f.o.t.	113/-
Cleveland No. 3, Glasgow	107/-
,, ,, Falkirk	104/-
Scottish hem. M/Nos. d/d	123/-*
Sheffield (d/d district)—	
Derby forge	100/6
,, fdry. No. 3	103/6
Lincs forge	100/6
,, fdry. No. 3	103/6
W.C. hematite	128/6*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	109/-
Staffs fdry. No. 3	109/-
Northants fdry. No. 3	107/6
Cleveland fdry. No. 3	109/-
Glengarnock, No. 3	137/6
Clyde, No. 3	137/6
Monkland, No. 3	137/6
Summerlee, No. 3	137/6
Eglinton, No. 3	137/6
Gartsherrie, No. 3	137/6
Shotts, No. 3	137/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0	to 13	15	0
Nut and bolt iron	11	12	6	to 12	2	6
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up.
Steel—						
Plates, ship, etc.	11	8	0	to 11	10	6
Boiler plts.	11	18	0	to 12	0	6
Chequer plts.				13	0	6
Angles				11	9	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ¾ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15d.
Rods	16d.
Tubes	20½d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	36/6
,, furnace	35/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	25/6 to 26/-
,,	28×20 ,,	51/- to 52/-
,,	20×10 ,,	36/6 to 36/9
,,	18¾×14 ,,	26/3 to 26/9
C.W.	20×14 ,,	22/6 to 23/-
,,	28×20 ,,	46/- to 46/6
,,	20×10 ,,	32/- to 32/6
,,	18¾×14 ,,	23/- to 23/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	12	0	0	to 13	0	0
Bars-hammered, basis	20	0	0	to 21	0	0
Bars and nail-rods, rolled, basis	19	0	0	to 20	0	0
Blooms	16	0	0	to 17	0	0
Keg steel	30	0	0	to 35	0	0
Faggot steel	20	0	0	to 25	0	0
Bars and rods dead soft st'l	19	0	0	to 20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
Aug.	26 ..	55	6	3	dec.	12/6
,,	27 ..	55	6	3	No change	
,,	30 ..	54	16	3	dec.	10/-
,,	31 ..	55	1	3	inc.	5/-
Sept.	1 ..	55	6	3	,,	5/-

Electrolytic Copper

		£	s.	d.		
Aug.	26 ..	62	0	0	dec.	10/-
,,	27 ..	61	10	0	,,	10/-
,,	30 ..	61	5	0	,,	5/-
,,	31 ..	61	5	0	No change	
Sept.	1 ..	61	5	0	,,	,,

Standard Tin (cash)

		£	s.	d.		
Aug.	26 ..	260	15	0	dec.	35/-
,,	27 ..	259	15	0	,,	20/-
,,	30 ..	260	0	0	inc.	5/-
,,	31 ..	261	5	0	,,	25/-
Sept.	1 ..	261	15	0	,,	10/-

Tin (English ingots)

		£	s.	d.		
Aug.	26 ..	260	15	0	dec.	35/-
,,	27 ..	259	15	0	,,	20/-
,,	30 ..	260	0	0	inc.	5/-
,,	31 ..	261	10	0	,,	30/-
Sept.	1 ..	262	0	0	,,	10/-

Spelter (ordinary)

		£	s.	d.		
Aug.	26 ..	23	1	3	dec.	13/9
,,	27 ..	23	1	3	No change	
,,	30 ..	23	1	3	,,	,,
,,	31 ..	23	0	0	dec.	1/3
Sept.	1 ..	22	16	3	,,	3/9

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Aug.	26 ..	25	12	6	dec.	13/9
,,	27 ..	25	12	6	No change	
,,	30 ..	25	12	6	,,	,,
,,	31 ..	25	12	6	,,	,,
Sept.	1 ..	25	8	9	dec.	3/9

Lead (soft foreign, prompt)

		£	s.	d.		
Aug.	26 ..	21	16	3	dec.	3/9
,,	27 ..	21	16	3	No change	
,,	30 ..	21	12	6	dec.	3/9
,,	31 ..	21	11	3	,,	1/3
Sept.	1 ..	21	15	0	inc.	3/9

Lead (English)

		£	s.	d.		
Aug.	26 ..	24	0	0	No change	
,,	27 ..	24	0	0	,,	,,
,,	30 ..	23	15	0	dec.	5/-
,,	31 ..	23	15	0	No change	
Sept.	1 ..	23	15	0	,,	,,

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 9	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	56 6	54 10	56 0	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 6½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	99 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 2	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 1½	97 0	100 0	100 0	110 6½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	86 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	88 9	87 6	87 6	86 10½	85 0	73 3½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	72 6	72 6	72 6	72 6	72 6	70 4½
1930	72 6	72 6	70 0	67 6	67 6	67 6	67 6	64 6	63 6	63 6	63 6	63 6	66 11½
1931	59 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 7
1932	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6
1933*	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6
1934*	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	66 10½
1935*	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	69 4½	70 0	67 10½
1936*	70 0	70 0	70 0	70 0	70 0	70 0	75 0	75 0	75 0	75 0	75 0	81 0	73 0
1937*	81 0	81 0	81 0	81 0	81 0	81 0	101 0	101 0	—	—	—	—	—

* Delivered Middlesbrough area. Prior to 1933, prices were f.o.t. furnaces.

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